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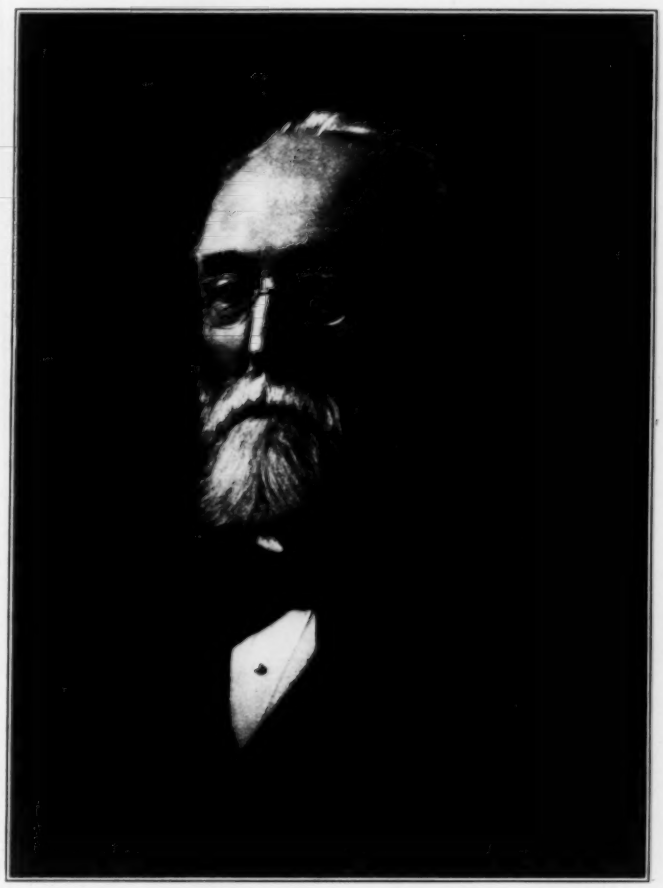
AN ACCOUNT OF THE ENGINEERING WORK OF E. D. LEAVITT

By F. W. DEAN, BOSTON, MASS.

Member of the Society

A brief account of the life of the late E. D. Leavitt, Past-President, Am.Soc.M.E., was published in THE JOURNAL for April, 1916. In view of the interesting character of Mr. Leavitt's work, however, and of the influence which it had upon good design, particularly in relation to water works and mining machinery, it was desired to place on record a more complete statement of his life and work with illustrations of some of his most characteristic designs. Accordingly, a paper was prepared by Mr. F. W. Dean, who was closely associated with Mr. Leavitt and is intimately acquainted with his accomplishments. This paper is to be presented at the Annual Meeting and is here published in abstracted form with a selection of a few of the engravings.



THE LATE ERASMUS DARWIN LEAVITT, PAST-PRESIDENT AND HONORARY MEMBER OF THE SOCIETY, AN ACCOUNT OF WHOSE STRIKING WORK IN THE DESIGN OF LARGE STEAM ENGINES AND OTHER MACHINERY WILL BE GIVEN BY MR. F. W. DEAN AT THE FORTH-COMING ANNUAL MEETING

E. D. LEAVITT received his education in the public schools in Lowell, Mass., learned the machinist's trade in the Lowell Machine Shop, was assistant foreman at Harrison Loring's works at South Boston, was chief draftsman at the works of Thurston, Gardner & Co., at Providence, entered the Navy in 1861, and resigned therefrom in 1867. At this time he began the office practice of mechanical engineering, and on account of the times and his ability he achieved great success; not, however, without some discouragements.

I have understood that his first steam engine was designed for Crozer's cotton mill, in Chester, Pa., and built by I. P. Morris & Co., Philadelphia. This was a simple horizontal engine with a steam chest as long and wide as the cylinder. The chest contained a very large main valve worked by an eccentric and having a cut-off valve on its back at each end worked by a cam. The steam exhausted into the main valve which was hollow, and from this passed out through a special exhaust port. The main valve, being in a chest of live steam and having exhaust steam within, formed a condenser to some extent, and to persons who knew of Mr. Leavitt's great efforts in general to secure economy this was a subject of comment. Later he used the same design for the Brooklyn Bridge engines and for those of the El Callao Mining Co. of Venezuela. He appeared to be attached to this design and spoke of it as his cheap engine, but never mentioned its obvious defect.

Mr. Leavitt was firmly of the opinion that the best valve for a steam engine was the gridiron and he always used it except in the few cases mentioned above. Mr. Leavitt claimed that the gridiron valve was the only one that would remain tight indefinitely. The reason for this was that it has a great deal of wearing surface and no tendency to cock over and press more on one edge than the other, and that when operated by cams has a constant travel, except, of course, the cut-off valves as early cut-offs.

Mr. Leavitt used cams because they enabled him to secure exact and unchangeable motion to the valves.

The automatic cut-off feature was obtained by placing a cam on a hollow piece of shaft or sleeve through which the camshaft passed, and by suitable connection with the governor the cut-off cam could be advanced or retarded. This was accomplished by having a spiral slot cut in the camshaft and a straight one in the sleeve, a key made to fit both and moved by a sliding collar, which in turn was moved by the governor.

It is obvious that the governor moved the valve and therefore had to be large and powerful. For good governing this was not satisfactory, except for pumping engines, which ran slowly, and finally the governing apparatus was changed to that having a small high-speed governor whose function was to operate a balanced piston valve which admitted and exhausted water or oil under pressure to and from a hydraulic plunger and this moved the cut-off collar. Thus the governor had no

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 4 to 7, 1917. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

resistance to overcome except friction, and could be made as sensitive as desired. After the first trial of this governor it was always used.

Mr. Leavitt's fame began with the installation of the Lynn, Mass., pumping engine, built by I. P. Morris & Co., which made an advance in economy over anything which preceded it. Its economical performance was based upon coal consumed, and upon its trial in December 1873 it gave a duty of 103,923,215 ft-lb. per 100 lb. of picked Lackawanna anthracite coal, based upon water discharged over a weir. While the feedwater was weighed and indicator diagrams taken, no evaporative rate for the boilers nor rate of steam consumption for the engine was given in the report.

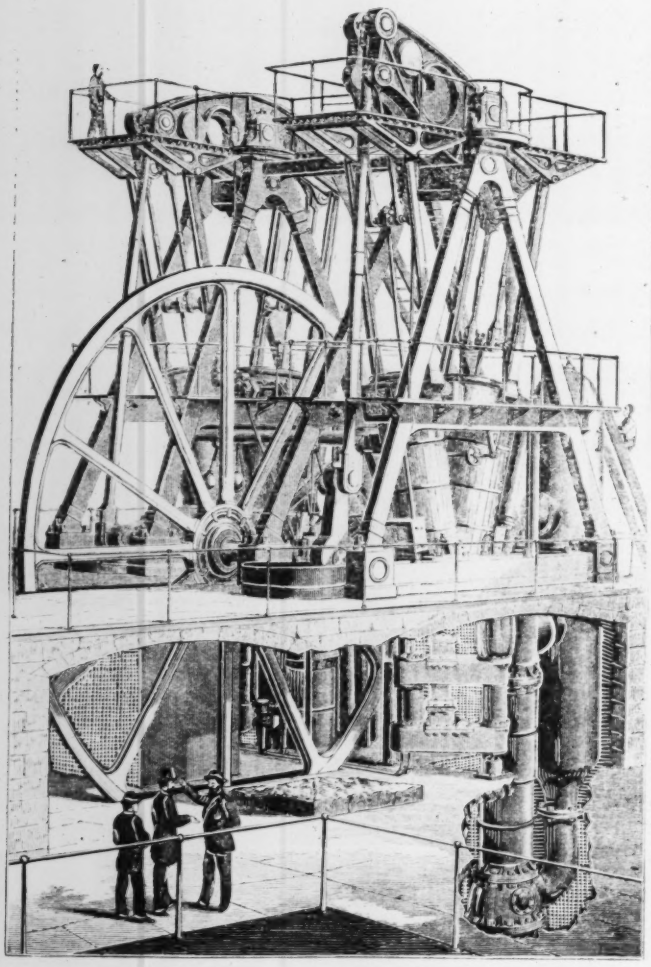


FIG. 1 THE LAWRENCE PUMPING ENGINE

The Lynn engine was soon followed by the Lawrence engines, also built by I. P. Morris & Co., which were tested for duty based upon 100 lb. of coal consumed and water discharged as determined by weir measurement. The test was made on May 2 to 6, 1876, and the duty was 96,186,979 ft-lb. per 100 lb. of Cumberland coal. The boilers were of an excellent design of the locomotive type and ought to have given a very high evaporation if properly fired. They only evaporated 8.27 lb. of water and 8.69 lb on different tests per pound of coal from feed at 100 deg. fahr. and pressure at 89 lb. This was attributed to poor coal, but must have been due to poor firing. In those days calorimeter tests of coal and analyses of escaping gases were seldom made. Here again, while feedwater was weighed and indicater diagrams taken, the steam rate of the engine was not worked out.

Fortunately Park Benjamin's Scientific Expert Office tested one of the Lawrence engines in 1879 after the engine was over three years old. The principal data and results were as follows:

Date	July, 1879
Duration of test, hr.	15.1
Kind of coal used	Cumberland bituminous
Diameter of high-pressure cylinder, in.	18
Diameter of low-pressure cylinder, in.	38
Diameter of plunger, in.	18.5
Stroke of steam pistons and plunger, ft.	8
Diameter of flywheel, ft.	30
Clearance of high-pressure cylinder, per cent: top, 2.56; bottom,	2.31
Clearance of low-pressure cylinder, per cent: top, 1.54; bottom,	1.82
Steam pressure above atmosphere, lb.	89.5
Vacuum, in.	27.4
Revolutions per minute, average	13.62
Discharge of pump in 24 hr. by plunger displacement, gal.	4,401,272
Duty per 100 lb. of coal consumed, based upon plunger displacement, ft-lb.	111,548,925
Temperature of feedwater, deg. fahr.	119
Temperature of escaping gases, deg. fahr.	358
Coal consumption per sq. ft. of grate per hr., lb.	8.38
Actual evaporation per pound of coal, lb.	10.13
Equivalent evaporation from and at 212 deg., lb.	11.49
Equivalent evaporation per pound of combustible from and at 212 deg., lb.	12.24
Coal used per indicated horsepower per hr., lb.	1.63
Feedwater used per hr., lb.	2437
Feedwater used per indicated horsepower per hr., lb.	16.48
Condensation in high-pressure cylinder jacket per hr., lb.	118
Condensation in low-pressure cylinder jacket per hr., lb.	160

In this table we have means of judging of the economical performance of both boiler and engine. The former was among the best and the latter was probably as good as that of any steam engine up to that time. There appears to have been no determination made of the moisture in the coal or in the steam.

The perspective drawing given in Fig. 1 and taken from the Park Benjamin report gives a good idea of the Lawrence engines, and serves the same purpose for the Lynn engine, there being one engine in the latter case.

THE BOSTON SEWAGE ENGINES

When the City of Boston undertook to dispose of its sewage by discharging it into the ocean south of the harbor limits, it became necessary to raise it about 40 ft. near the north shore of Dorchester Bay. Mr. Leavitt designed two vertical compound flywheel engines for this purpose, which are shown in Fig. 2. These were built by the Quintard Iron Works, New York, and were vertical inverted compound flywheel beam engines of the following general dimensions:

Diameter of high-pressure cylinder, in.	25½
Diameter of low-pressure cylinder, in.	52
Diameter of each of the two plungers, ft.	4
Stroke of each piston and plunger, ft.	9
Number of plungers	2
Number of revolutions per minute, nominal	10¾
Capacity in 24 hr., nominal, gal.	25,000,000

The cylinders were steam-jacketed and there were tubular reheaters between the high- and low-pressure cylinders, one being between the upper ends of the cylinders and the other between the lower ends.

In 1885 one of the engines and its twin-furnace locomotive-type boiler were tested by Dexter Brackett with the following results:

Dates of trials, 1885	Mar. 24-25	May 1-2
Duration	24h. 43m.	24h. 3½m.
Revolutions per minute, average	13.17	13.42
Total lift, ft.	37.80	42.43

Total dry coal consumed, lb.	8,307	9,478
Duty per 100 lb. dry coal, ft-lb.	125,450,000	122,400,000
Mean boiler pressure, lb. per sq. in.	99.4	98.6
Mean vacuum in condenser, in.	28.1	28.0
Total plunger displacement, gal.	33,038,000	32,778,000
Total discharge by weir, gal.	30,224,000	31,256,000
Average slip, per cent	8.5	4.6
Approximate indicated horsepower	251.5	290.2
Plunger horsepower, no allowance for slip	212.9	243.5
Mechanical efficiency, per cent	84.66	83.90
Approximate coal used per i.hp. per hour, lb.	1.33	1.35
Approximate steam used per i.hp. per hour, lb.	13.89	14.09

In 1889 he designed a larger triple-expansion engine for the same place.

THE LOUISVILLE PUMPING ENGINE

The next pumping engine of Mr. Leavitt's design to attract attention was the Louisville engine, built by the I. P. Morris Co., and it was the first to be thoroughly tested. The test was conducted by Dexter Brackett and F. W. Dean and lasted 144 hr. 10 min. without stopping.

The engine was arranged similar to the Boston sewage engines, but had the flywheel shaft near the floor level and at one end of the bedplate instead of being elevated and between or just below the lower ends of the cylinders. The reheaters were of the same type.

The following are the general results of the test:

Diameter of high-pressure cylinder (bore), in.	22.21
Diameter of low-pressure cylinder (bore), in.	54.13
Diameter of high-pressure piston rod, in.	5.50
Diameter of low-pressure piston rod, in.	6.00
Stroke of each piston, ft.	10
Mean clearance volume of high-pressure cylinder, per cent.	1.585
Mean clearance volume of low-pressure cylinder, per cent.	1.530
Diameter of each differential plunger, in.	24 & 24 1/16
Stroke of each differential plunger, ft.	7
Diameter of flywheel, ft.	30
Duration of trial	144h. 10m.
Revolutions per minute, average	18.574
Average steam pressure at the engine, lb. per sq. in.	137
Back pressure on low-pressure piston, lb. per sq. in.	0.95
Total head, ft.	193.35
Total dry steam used by engine in cylinders and jackets, lb.	1,127,533
Dry steam used per i.hp. per hour including jacket steam, lb.	12.156
Horsepower of high-pressure cylinder	279.00
Horsepower of low-pressure cylinder	364.40
Horsepower of both cylinders	643.40
Horsepower of plungers	599.10
Mechanical efficiency of engine, per cent	93.12
Duty per 1000 lb. of dry steam by plunger work, ft-lb.	150,838,000
Duty per 1,000,000 B.t.u. by plunger work, ft-lb.	151,672,000
Avg. capacity of engine in 24 hr. by weir, U. S. gal.	16,489,420
Avg. capacity of engine in 24 hr. by plungers, U. S. gal.	17,081,350
Average slip of plungers, per cent	6.74

THE WASHINGTON MILLS ENGINES

These are the only Leavitt power engines that have ever been thoroughly tested as far as I know. They were put in under a guarantee and tested by John T. Henthorn and E. D. Leavitt, Mr. Leavitt being represented by A. M. Mattice. They were built by the Dickson Mfg. Co., Scranton, Pa., and were a pair of 30-in. by 60-in. steam-jacketed horizontal non-condensing engines running at 60 r.p.m. and driving a 30-ft. wheel grooved for thirty 1¾-in. ropes. The test was made after the engines has been in operation about three years, and the general results obtained are as follows:

Duration of test (June 12-19, 1890)	One week, mill hours
Running time	61 hr. 41 min
Average steam pressure at engines, lb. per sq. in.	132.2
Average revolutions per minute	58.82
Average back pressure, lb. per sq. in.	7.98
Average indicated horsepower both engines	1199.2
Net moist steam used by engines (including jackets) per i.hp. per hour, lb.	23.16
Per cent of steam used by jackets	3.05

DETAILS OF ENGINE DESIGN

Cams. In the early Leavitt engines the cams were made with grooves in the side and the throws were inserted hardened steel. The high-pressure cut-off cam, although it appeared to be grooved, was not in fact. It consisted of two cams, one recessed and overhanging the other. The opening cam was secured to the camshaft and the cut-off cam to the hollow shaft which was controlled by the governor. The rolls which were actuated by the cams were on pins overhung from rockers.

When the hoisting engine Superior was built, having cylinders 40 in. and 70 in. by 6 ft., grooved cams were used. The camshaft was located near the floor level, and as the engine was vertical and inverted, the valve rods were very long and heavy. It was intended to run the engine at 60 r.p.m., but the valve gear would not operate satisfactorily, I have understood, at over 35 r.p.m. The noise was so great at higher speeds that conversation could not be carried on nearby without shouting at close range, and breakages of the cut-off cams and levers occurred. The outcome of the trouble was that a new valve gear was designed which was light and possessed small inertia stresses. In the case of the Superior the camshaft was raised to a level with the middle of the cylinders and was supported, together with the valve gear, by means of brackets attached to the valve-chest bonnets. The valve rockers for the lower valves extended downward, and for the upper valves upward, from the camshaft.

The outside cams had rolls on opposite sides rotating on pins in forked rockers so that there were no overhung pins. The pair of rockers of one cam were connected together by links, and the throws of the cams were so formed that both rolls always touched the cams. The Superior was started with the new valve gear in the latter part of 1883, and has been running ever since, from 20 hours to 24 hours per day, with the utmost satisfaction.

Fig. 3 shows the Superior with a new valve gear, while the paper by Mr. Leavitt in Vol. 2 of Transactions (facing p. 120) shows it with the original gear.

Cylinder Design. The Leavitt cylinders were always steam-jacketed and had the jacket cast on. Mr. Leavitt always feared leakage with cylinders having liners. The jacket was cast with an opening all round the center and this was covered with a copper ring with one corrugation. The ring was secured by two rows of tap bolts on each side. The division of the jacket wall in this way was the result of some serious disasters. The jackets of the Lynn and Lawrence pumping engines were cast without the division and straight, with the result that one or more of them cracked and had to be replaced. A cylinder of a steam stamp at the Calumet and Hecla Mine made without provision for jacket expansion broke and went through the roof of the building.

The steam chests of the cylinders were always cast on, and sometimes the crank-end head was cast in, and sometimes it was separate. Fig. 4 shows a typical cylinder. This design shows the inner wall serrated in order to provide more surface for contact with steam and thus render jacket action more active. This was a feature not always used, and was borrowed from the practice of a well-known Belgian engineer.

Valves and Valve Seats. The valves were rectangular plates with one end formed to receive T-ended valve stems. The ports were slotted. The seats were secured to the cylinder by means of studs, and the surfaces of contact between the cylinder and seat were scraped to continuous contact. The bridges between the ports of the seats were each provided with

an oil groove. There were two yokes secured to the seats for preventing the valves from leaving the seats too far. In vertical cylinders the seats were somewhat inclined so that the valves would tend to rest against them.

In order to fill up all unoccupied spaces blocks were screwed in or cast on to reduce the clearance volume.

In designs made since about 1888, the clearance volume was still further reduced by casting V-shaped forms on the cylinder ports under the bridges of the valve seats. This added to the condensing surface of the clearance, and in fact all other devices for diminishing clearance did this also, and I have often thought that whatever may have been gained by reducing clearance was lost by the increase in surface. All Leavitt engines made an indicator diagram with a long drop in the compression line. The compression would go on for a time and then there would be a collapse which would not be recovered. I think that this was caused by condensation in the clearance, which in turn was caused by the great amount of surface in the valve-seat ports and other parts.

There was always means of operating the valves by hand, and this involved a handwheel something like the steering wheel of a steamboat except that it was of steel. There were two clutches moved by a lever, one of which engaged the camshaft with a driving shaft and the other engaged it with the handwheel. One of course was engaged when the other was disengaged. The operation of starting consisted chiefly in placing the valves in the proper position, opening the throttle and throwing the clutches at the proper time. The skill required to do this was easily acquired.

THE LEAVITT BEAM ENGINE

Mr. Leavitt was very fond of the inverted beam engine for the reasons that it made a very low engine and was long and stable in the direction of motion of the parts, and cheapened the building by making it lower. The beam was generally made of air-furnace or gun iron, but later of steel castings. The weights of the beams and reciprocating parts were very great and they all moved in the same plane, but no trouble came from this in practice.

The usual place for crossheads was above the beam, but they have been placed below, and in this case the links from the crossheads extended upward to the beam pins. The beams were generally made in two "flitches" (to use Mr. Leavitt's word), but sometimes in a single piece. The connecting-rod

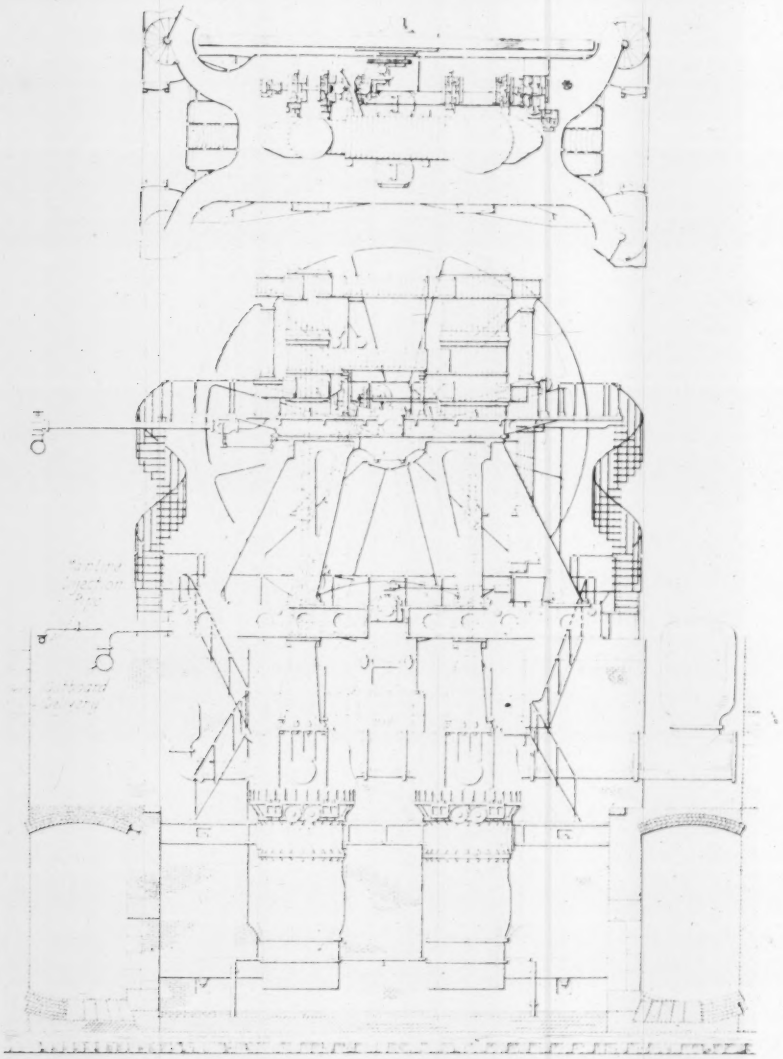


FIG. 2 BOSTON SEWAGE PUMPING ENGINE

pin sometimes was overhung from the beam, but oftener was between the flitches.

In compound engines the high-pressure cylinder was above one end of the beam and the low-pressure cylinder above the other, but in 1886 Mr. Leavitt began the design of triple-expansion engines, which he arranged by having the high and intermediate cylinders above one end of the beam and the low-pressure cylinder above the other. The high and intermediate pistons had coincident motions. The steam pressure used for compound engines was 135 lb. and for triple-expansion engines 185 lb.

Reheaters were used in each case, and it may here be remarked that Mr. Leavitt had great difficulty in making the reheater tubes tight in the tube plates.

In some of the later triple-expansion or three-cylinder compound engines three beams were used and each piston was connected to one end of each beam, and there were three connecting rods and three cranks 120 deg. apart. These were

HOISTING MACHINERY

For many years the method of hoisting at both the Calumet and the Hecla mines was by means of constant-running engines, which also drove air compressors. The hoisting drum was on a shaft to which it was not secured except by means of a clutch. There was also a brake to prevent the drum from moving and holding it fast whether the engine was running or not. Both the clutch and brake were operated by means of hydraulic pressure from an accumulator, and the levers for controlling them were interlocked so that the clutch and brake could not be thrown on simultaneously. The clutch cylinder was secured to an arm of the flywheel and the water was introduced through the shaft which was bored for the purpose. The brake was secured to a post which was firmly bolted to the foundation. The brakes and clutches were of the strap type and worked on wood. There was an indicator to show the position of the skip in the shaft, and an anti-overwinding device, which I believe was never used. The drum centers were in

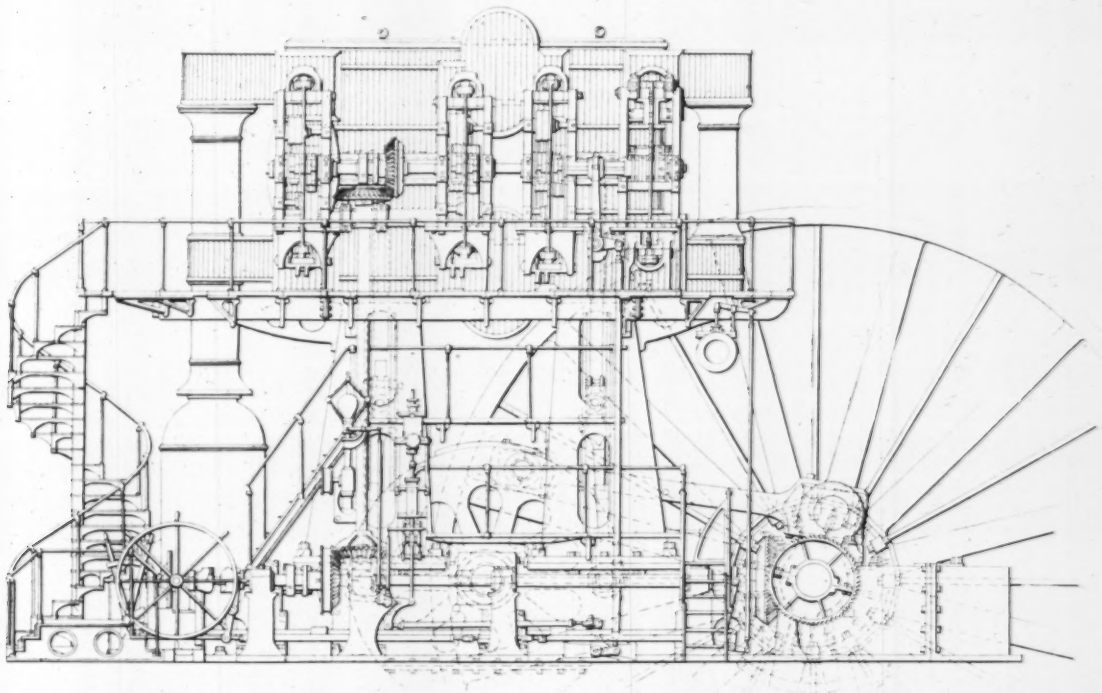


FIG. 3 THE "SUPERIOR" ENGINE

certainly beautiful pieces of mechanism and operated to perfection. The first such engine was the Riedler pumping engine of the Boston Water Works, built in 1894 and shown in Figs. 5 and 6.

The engine at the Bethlehem Steel Co., designed by Mr. Leavitt for pumping water for the forging press and built by the I. P. Morris Co., is another example of this arrangement, and there are three of them driving electric generators at the stamp mill of the Calumet and Hecla Mining Company, as well as several hoisting engines of this type. In the stamp-mill engines, although gridiron valves were used, they were not operated by cams. They were opened by eccentric rods and were provided with latches and dashpots as in Corliss gears. This feature of the valve gear was caused by the engines having been built for a reversing hoisting gear, and the valves could be better controlled by a reversing link when so made than if reciprocating cams were used as on the engines Minong and Siscowit.

halves, and were lined continuously with babbitt metal. The rope faces were sometimes straight and sometimes conical, and the arms were of wrought rods.

When Mr. B. S. Whiting entered the employ of the Calumet and Hecla Mining Company the Whiting system of hoisting was introduced. This was first used at the Red Jacket shaft, and consisted of two cages, one descending and the other ascending, with a rope from the bottom of one to the bottom of the other, and thus being balanced. The engine drove a pair of narrow-faced drums with two wraps over both drums. The drum shafts were coupled together like the wheels of a locomotive and the engines were reversing.

The introduction of reversing engines brought new problems in engine design and the first engines were the Minong and Siscowit. These were vertical, triple-expansion condensing beam engines using 185 lb. steam pressure. They had cam-operated gridiron valves with automatic cut-offs on the high-pressure cylinders. The cams were reciprocating. The

Walschaerts gear was used, the lap and lead were derived from the beam shaft, and the reversal was affected by hydraulic mechanism.

Afterward there were several other installations of the Whiting system with other types of engine.

COMMERCIAL ENGINES

Mr. Leavitt recommended quite a number of commercial engines for hoisting, pumping and for driving air compressors, but they were usually for spare units or for temporary purposes. For instance, the Superior originally drove hoisting drums on one side and air compressors on the other. On the air-compressor side and beyond the compressors there was a spare Corliss engine which could be coupled on to drive the compressors if the Superior had to be stopped. At the other side there was a 40-in. by 60-in. horizontal condensing Leavitt engine for driving the hoisting drums in an emergency. At the Hecla mine there was an exactly similar arrangement with the Leavitt vertical compound condensing beam engine Frontenac in the middle driving in both directions, with a spare commercial Corliss engine at each end. Similarly there were various commercial engines in other hoisting houses, and not

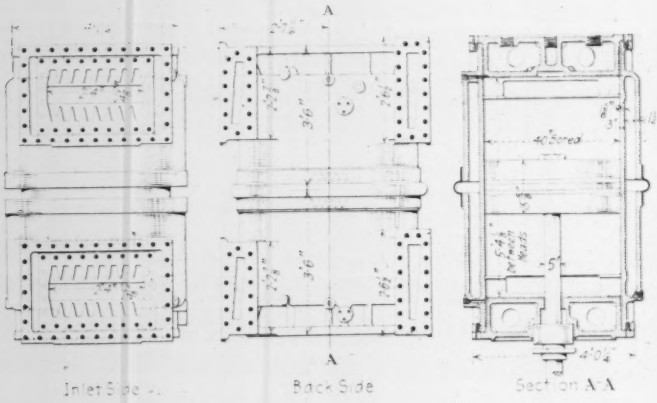


FIG. 4 TYPICAL ENGINE CYLINDER

always spare engines. In such cases the commercial part was the smallest.

AIR COMPRESSORS

A great many air compressors are needed at the Calumet and Hecla Mines, and up to a certain time commercial compressors were used. Soon after the installation of wet compressors at the St. Gothard Tunnel in Switzerland, Mr. Leavitt was impressed with the advantages of the type and designed a pair of 42-in. by 60-in. by 30-r.p.m. wet compressors. These were placed in the Hecla hoisting house and were similar to double-acting pumping engines, the plunger causing water to rise and fall in two vertical cylinders or chambers—one at each end. At the top of each of these chambers there was a valve deck having inlet and discharge air valves, and below there were spray nozzles for cooling the air. The spray water was pumped by a small attached pump. There was a separator in which the vapor settled, and the quality of the air was satisfactory. These compressors were successful, but later when similar ones were installed at the Calumet hoisting house to run at double the speed, as I understand, they were unsuccessful on account of that speed and were replaced by dry compressors.

PUMPING ENGINES

Something has already been said about Leavitt pumping engines, and it is well to state that the Lynn type of engine was used only at Lynn and Lawrence. When the first engines were designed for the Calumet and Hecla Mining Company they were inverted, and with the high-pressure cylinder inclined for the purpose of having the cylinders as near together as possible and thus reducing certain losses. Between the near ends of the cylinders there was a single valve which was both high-pressure exhaust and low-pressure inlet. At the distant ends there were two valves which moved simultaneously, one being the high-pressure exhaust and the other the low-pressure inlet, although the Lynn engine had only one valve between the distant ends of the cylinders. Later, when the Boston sewage, Fig. 2, and the Calumet Pond pumping engines were designed the cylinders were all vertical and reheaters were used.

The greatest requirement for water at the Calumet and Hecla mine is at the stamp mill, which is some six miles from the mine, on Torch Lake, which is an inlet from Lake Superior. The pumping engine Ontario and the large-capacity spare pumps Huron and Arcadian are there. The engine Michigan is the largest engine at the stamp mills, and has cylinders 18 in., 27¾ in. and 48 in. by 90 in. and two plungers with the suction ends 48 in. by 90 in. The number of revolutions per minute was intended to be 30 and the capacity 60,000,000 gal. in 24 hours. It runs usually at 28½ r.p.m. The head is about 40 ft. This engine uses steam of 185 lb. pressure. The Michigan was a bold design, as it is supported by wide, straddling cast-iron columns as shown by Fig. 7. This engine had pump cylinders which were oval at the valve level for accommodating the valves, and were of great size, being 9 ft. 10 in. wide the narrow way and 14 ft. 2 in. the other way. They were cast of gun iron.

The Lynn and Lawrence engines had each one plunger, this being of the Thames-Ditton type, being single-acting on the suction and double on the discharge, with a few large double-beat metal valves. This type of plunger was not used later, but instead of this the differential plunger was used. This plunger is of two diameters, the lower part having twice the cross-section of the upper. The lower section passed through the discharge valve deck and the upper section through the top of the pump. This plunger is single-acting on the suction and double on the discharge, and two were always used, one being under each end of the beam. The differential plunger was invented by Mr. Leavitt, but he soon found that he was anticipated in this.

The sewage engines designed for the City of Boston had each two plungers of a single diameter.

The largest Leavitt pumping engine, designed in 1889 and built by the I. P. Morris Co., was the last sewage engine for Boston, already referred to, the cylinders being 18½ in., 33 in., and 52¾ in. by 10 ft. stroke. The plungers, of which there are two, are 60 in. in diameter by 10 ft. stroke, and the rated capacity 75,000,000 gal. in 24 hours against a head of about 40 ft. The speed is 18 r.p.m.

The Cambridge engine, designed in 1895 and built by the De La Vergne Machine Co., New York, was a triple-expansion engine using 185 lb. pressure. The cylinders were 18½ in., 33 in., and 52¾ in. by 7 ft. 6 in. stroke, and the plungers (two differential) 19⅜ in. and 27¾ in. by 7 ft. 6 in. stroke. Its rated speed was 32 r.p.m., and this gave a piston and plunger speed of 480 ft. per min. and a capacity of 20,000,000 gal. in 24 hours. If the engine had run slower it would have been more satisfactory.

At about the time the Cambridge engine was designed Mr. Leavitt was commissioned with the design of a pair of engines for the city of New Bedford, Mass., which were built by the Dickson Mfg. Co. It was decided to make these engines compound and to use 185 lb. pressure, in order to compare their economy with that of the Cambridge engine using the same steam pressure and being triple. I do not know whether the comparison was ever made, but the station economy of the New Bedford engines is better than that at Cambridge. The steam cylinders of the New Bedford engines are 16⅜ in. and 36¼ in. by 7 ft. 6 in. stroke, and the pump plungers are 13.7 in. and 19⅜ in. by 7 ft. 6 in. stroke.

A feature of some Leavitt pumps is that under each suction valve there is a tube several inches long with a bell lower end, the object being to form a suction air chamber between the tubes. I am not aware that any benefit from this construction was identified. It was used on some Calumet and Hecla engines, and also on the Cambridge and New Bedford engines.

Mr. Leavitt was a great believer in steam jackets, and used boiler pressure for this purpose, even in low-pressure cylinders of engines using 185-lb. steam. It is known that these engines exhausted steam considerably superheated into the condensers, but I believe that Mr. Leavitt held that there was great benefit in drying the steam as much as possible before it left the cylinder.

The Leavitt pump valves were not as small as those used in commercial engines. They were usually faced with leather and had separate adjustments for the lift and tension of the spring. For sewage engines the valves were rectangular and hinged on one side, each covering an opening of 4 in. by 16¾ in. in the latest engine.

Mr. Leavitt became acquainted with Professor Riedler, of Berlin, and I believe acquired the right for a time to use the Riedler pump in the United States. The Riedler pumping engine for the city of Boston, already referred to (Figs. 5 and 6) was a triple-expansion three-cylinder, three-beam, three-connecting rod, three-crank and three-pump engine, and was the only one designed by Mr. Leavitt.

The pumps were inclined and double-acting, located at the rear of the engine and operated by connections to the beams. Each pump had a single suction and a single discharge valve at each end operated by mechanism.

The engine was built by the Quintard Iron Works, New York. As it was intended to surpass all previous efforts at economy, the results of a test made by some students of the

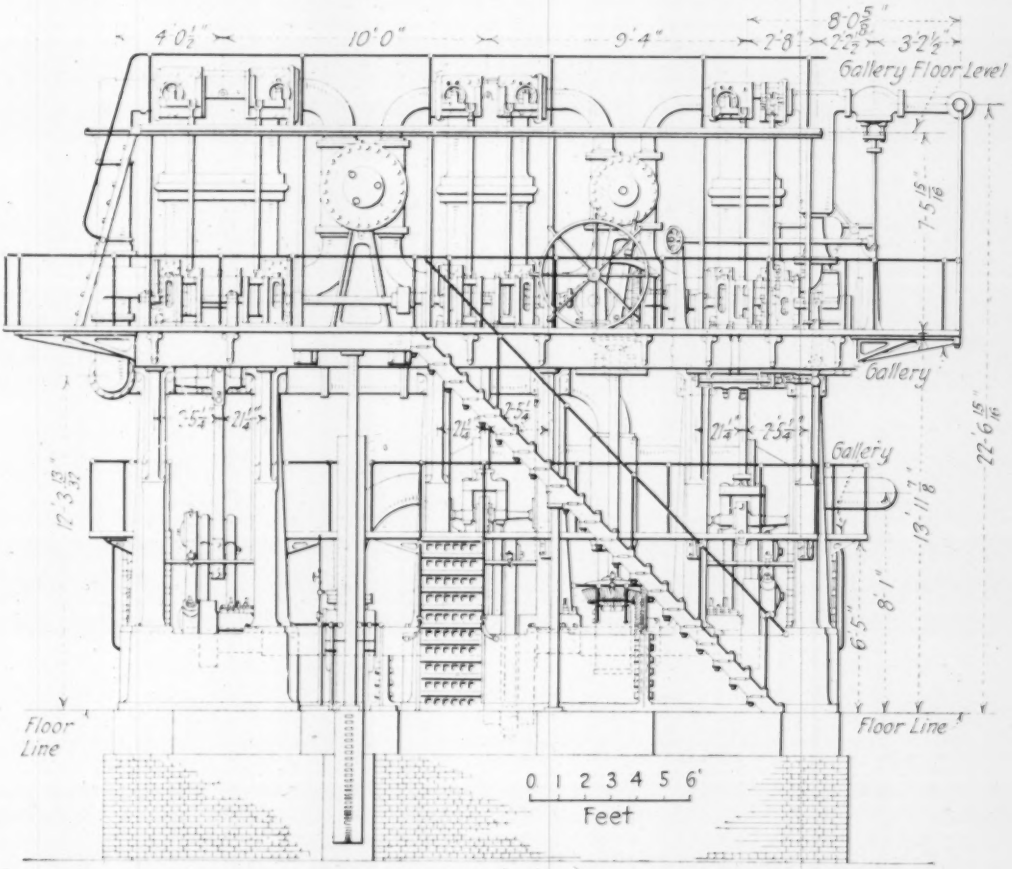


FIG. 5 RIEDLER PUMPING ENGINE

Massachusetts Institute of Technology under the direction of Prof. Edward T. Miller are herewith given:

Diameter of high-pressure cylinder, in.	13.7
Diameter of intermediate-pressure cylinder, in.	24.375
Diameter of low-pressure cylinder, in.	39
Stroke of each piston, in.	72
Diameter of each plunger, in.	17.5
Stroke of each plunger, in.	48
Rated capacity in 24 hours at 50 r.p.m., gal.	20,000,000
Type of condenser	surface
Steam pressure, lb. per sq. in.	185
Type of boiler	Belpaire locomotive
Duration of trial, hours	24
Average number of revolutions per minute	50.585
Average steam pressure at throttle, lb.	175.7
Average vacuum in condenser, in.	27.25
Average pressure in first receiver, lb.	46.5
Average pressure in second receiver, lb.	2.4
Average pressure in high and intermediate cylinder jackets, lb.	175.7
Average pressure in low-pressure cylinder jacket, lb.	99.6
Indicated horsepower of high-pressure cylinder	150.86

Indicated horsepower of intermediate cylinder	186.14
Indicated horsepower of low-pressure cylinder	238.66
Total steam horsepower	575.66
Total pump horsepower	529.86
Mechanical efficiency, per cent	92.
Friction, per cent	8.
Water discharged in 24 hours by weir measurement, gal.	21,016,000
Slip, per cent	1.83
Dry steam used per i.hp. per hour, engine only, lb.	11.22
Coal used per i.hp. per hour, whole plant, lb.	1.18
Duty per 100 lb. coal, ft-lb	150,045,000
Duty per 1,000,000 B.t.u., ft-lb	145,470,000
Duty per 100 lb. combustible, ft-lb	160,000,000

THE LEAVITT STAMP

The steam stamp devised by Mr. Leavitt for stamping rock containing native copper is a gigantic steam hammer about thirty-eight feet high above the foundation. See Fig. 8. When Mr. Leavitt began to study economy of steam for stamps he found great room for improvement, and then devised his well-known stamp. It has two pistons on the same rod, the upper one being considerably larger than the lower. Steam for the blow acts upon the top of the upper or larger piston and is admitted by a gridiron valve and exhausted by another to a condenser. Both valves are operated by cams. The space between the upper and lower pistons is constantly connected to the condenser. The space under the lower piston is occupied by live steam and serves to lift the stamp, and the steam thus used is churned into and out of a reservoir, and thence to and from the steam pipe. The lower piston enters a compression chamber at the bottom to limit the downward stroke, while the upward stroke is limited by a lower piston entering a dashpot.

As appears to have been the custom at the Lake Superior mines, the stamp anvil, which has been made of various weights, rested formerly on large maple spring timbers. In about 1900 these were omitted and the anvil placed directly on the foundation. By this means the output of the stamp was increased and the vibration of the surrounding territory diminished. There are 27 Leavitt stamps at the Calumet and Hecla stamp mills, each making 108 blows per minute.

The valve gear and condenser pump are driven from a shaft which serves a long line of stamps. Later, I understand, the exhausts of all of the stamps were taken to low-pressure turbines, with the result that some of the power engines were shut down, and considerable economy resulted.

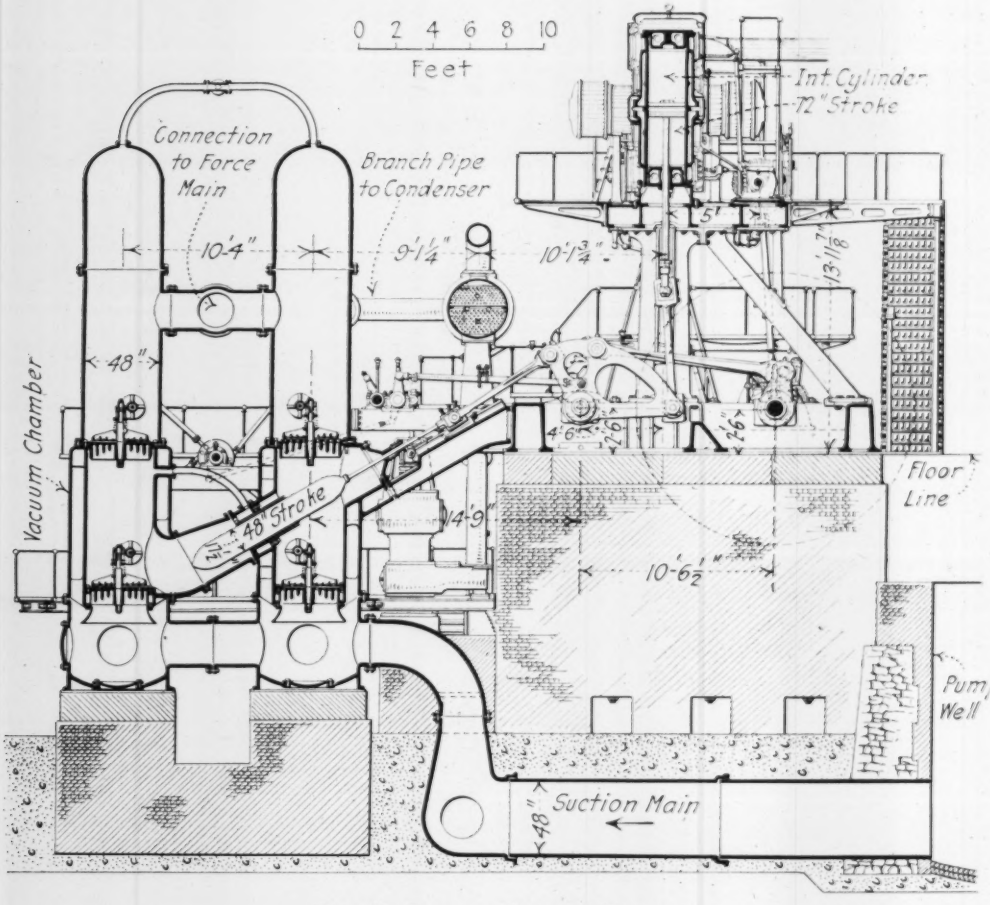


FIG. 6 RIEDLER PUMPING ENGINE

BOILER PRACTICE

Mr. Leavitt was a great advocate of the locomotive boiler and usually installed this type. I understand that before adopting it he designed some boilers for the Calumet and Hecla mine which were a sort of "elephant" boiler, and these were failures. After this the locomotive type was always used, and these were a great success. They had a firebox with a mid-water leg, thus forming two fireboxes. The mid-water leg extended forward from the firebox and formed two so-called flues to a single combustion chamber which ended at the tubeplate. The length of the flues was often 3 ft. 6 in. and the combustion chamber 4 ft. At the end of the grate there was a 20-in. firebrick wall, thus making the distance from the end of the grate to the tubeplate 9 ft. 2 in. In 1882, or thereabout, brick arches began to be used, as in locomotive practice.

Originally the boilers had a round top above the crown sheet,

but later, due to the writer's influence, the Belpaire form of firebox and method of staying was adopted. Up to about this time the joints in the barrel of the boiler were butted, both longitudinal and circumferential, but Mr. Leavitt was influenced to abandon the latter for lap joints. The longitudinal butt joint was, of course, preserved, and it is interesting to know that the prevailing form of butt joint used in this country, viz., that having a narrow outside and wide inside strap, was devised by Mr. Leavitt and Edward Kendall, of Cambridge, Mass., where Mr. Leavitt also lived. This joint was then thought to be the final word in joint efficiency and the drawing of the first boiler having it was made in 1879.

Why Mr. Leavitt did not adopt English practice in butt joints, with which he must have been acquainted, I do not know, but I suppose that he was seeking a joint of higher efficiency than that, as then designed, which had the straps of equal widths and all rivets in double shear.

The first Belpaire boiler he designed was for 135 lb.; others were designed for 185 lb. pressure. These boilers were very expensive, and as the largest had only 2900 sq. ft. of heating surface, the cost per square foot of heating surface was very high. It was, in fact, about $5.20 in 1887 for 90-in. boilers for 185 lb.

For mill work Mr. Leavitt used the horizontal return-tubular boiler, and some of them 78 in. in diameter carried 185 lb. pressure. For the New Bedford pumping engines he used cylindrical boilers with two Purves furnaces each and 3-in. tubes from the furnaces to a smokebox.

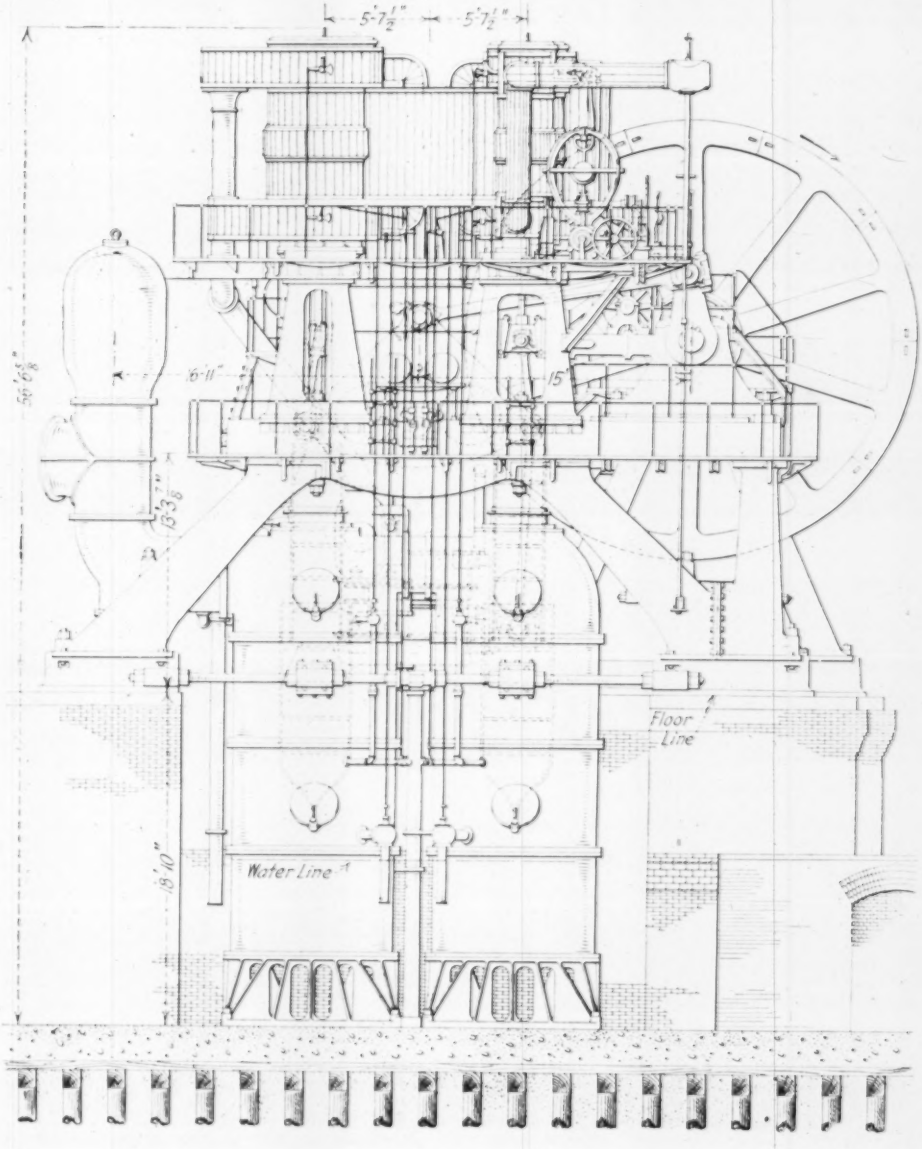


FIG. 7 MICHIGAN PUMPING ENGINE

CONSULTING ENGINEERING

So far as I know, Mr. Leavitt did not do much general expert work, but he acted as consulting engineer for a number of companies. Among them were Henry R. Worthington and the Dickson Mfg. Co. He designed the Penn Avenue shop for the latter company at Scranton, Pa. This was a well-lighted shop with a high center bay and traveling crane, and a gallery on each side.

Mr. Leavitt's influence upon good designing in this country must have been great, and the many draftsmen whom he em-

ployed and who have scattered throughout the country must have exerted a great and silent influence upon excellence in design, which they owe to him. I feel that William Sellers, E. D. Leavitt, John E. Sweet and Charles T. Porter were the best machine designers that this country has produced up to their time. Mr. Leavitt willingly gave credit to the other three for much of his own good work.

According to the *Frankfurter Zeitung*, the newly manufactured compressed cellulose piping has proved very satisfactory in chemical factories and also in mining works. The new material, it is said, is absolutely non-porous, is considerably lighter than iron, can be worked like wood, and

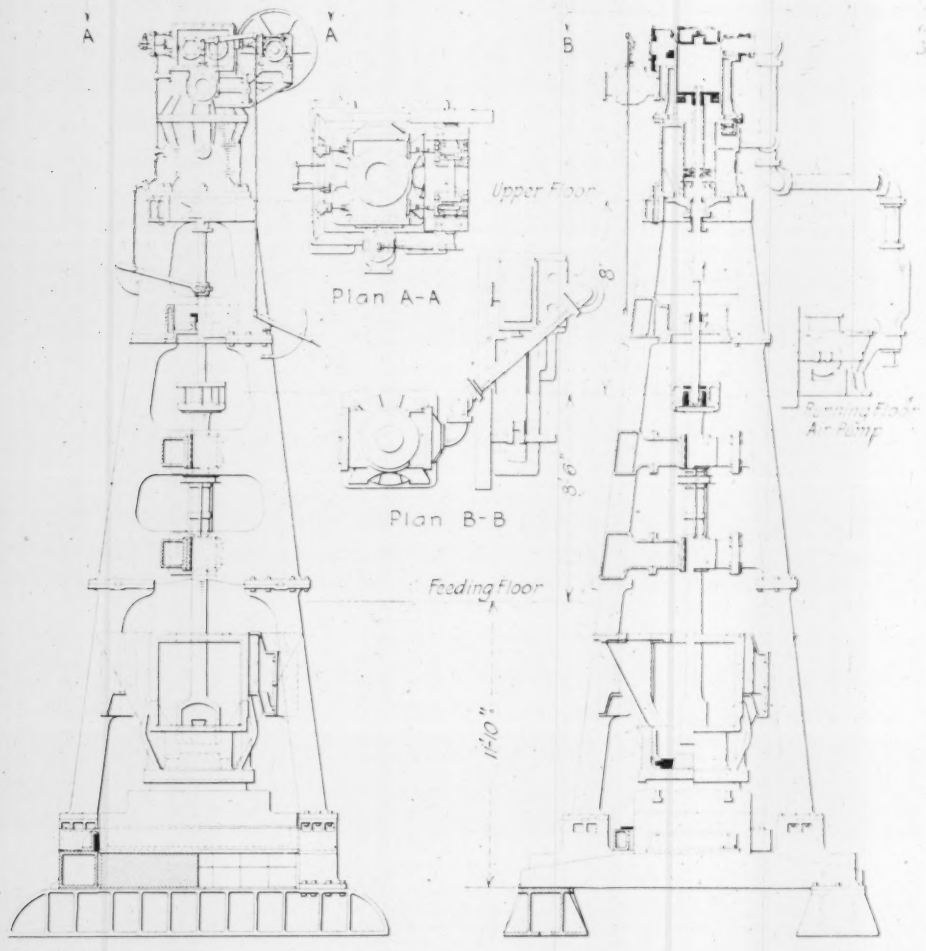


FIG. 8 LEAVITT ORE STAMP

is consequently easily moved and repaired. As cellulose is a bad conductor of heat, it requires no particular protection against heat; it also resists chemical influences better than iron. Cellulose tubes are suitable for conducting hot and cold air, and for corrosive gases which eat into iron conductors very quickly. They are not suitable, however, for steam.—*The Engineer* (London), August 17, 1917.

Further improvements are unquestionably possible in turbines operating under present conditions, and improvements are also possible in boiler-room equipment and practice, but the results now reached in modern plants are so near to those theoretically attainable under the conditions of operation that no improvements of sweeping magnitude may be expected along such lines. It seems probable that the conditions of operation will have to be radically changed if any great reduction in fuel per unit is to be achieved.

Two revolutionary suggestions to this end have been made within the last few years. It was pointed out by Robert Cramer that increasing the initial pressure by several hundred pounds would make it possible to increase materially the theoretical efficiency of present-day cycles, and S. Z. de Ferranti suggested a new form of turbine cycle in which much greater use was made of superheated steam.

The highest steam pressures now commonly used with steam turbines are in the neighborhood of 200 to 250 lb. per sq. in., and the highest steam temperatures are about 600 deg. fahr., corresponding roughly to about 200 deg. of superheat. The highest pressures for which boilers can be built and the highest temperatures which turbine parts can be made to stand are still unknown. The steam tables carry pressures to 600 lb. abs. and total temperatures to about 1000 deg. fahr.

The suggestion of Ferranti contemplated a radical change of cycle. At the present time it is impossible to say whether turbines will ever be constructed commercially to operate on this cycle. There are many mechanical difficulties to be overcome, but they do not appear to be of as great magnitude as were those that were met and overcome in the early days of turbine construction. It is therefore conceivable that turbines may be built to operate on the Ferranti cycle or some modification thereof.—C. F. Hirshfeld, Mem. Am.Soc.M.E., in *Power*, September 18, 1917.

THE TRUMBLE REFINING PROCESS

A New Departure in the Methods of Oil Distilling, Effecting a Marked Saving in the Percentage of Oil Required as Fuel

By N. W. THOMPSON,[1] SAN FRANCISCO, CAL.

THE first step in the refining of oils is to obtain the different fractions or distillates of the crude oil. Some of these are ready marketable products and others need treatment. To obtain these distillates it is necessary to distill or boil them over in a still and separate them according to boiling points.

The old method was to fill a cylindrical still with the crude oil and boil off the lighter distillates, then the next heavier, and so on. After being condensed these distillates were run through a steam still and the still kept to a certain temperature until all of the lighter fraction or first cut was obtained, then the temperature was raised for the next fraction, and so on.

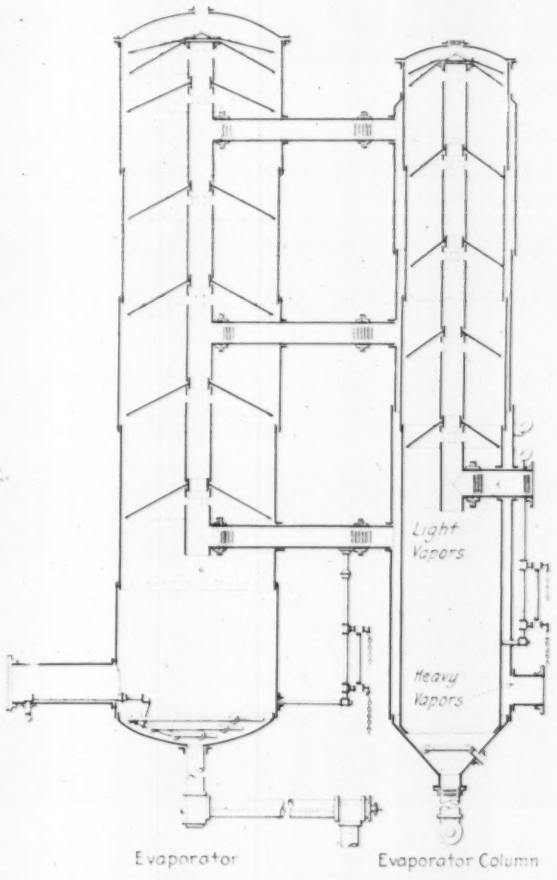


FIG. 1 EVAPORATOR AND EVAPORATOR COLUMN

A large number of the refineries at the present time continue this system, and others put a number of crude stills in series and run them continuously,—that is, the residuum or bottoms of the first still run to the second still where they are heated to a higher temperature, and so on to the last still, from which the residuum flows to a cooler and then to the tank. This residuum is generally fuel oil.

In these stills there is a large volume of oil over the fires and also an expensive installation to build and maintain. There can be no seams in the bottom of the stills necessitating very large plates, and it is necessary to have perforated steam pipes in the bottoms to agitate the oil so as to keep the bottoms from burning, etc.

Large surfaces are necessary when the heating is done in this way. There is low heat transfer on account of slow velocities and the low specific heat of the liquid and about one-third of the surface of the still cannot be heated and must be highly insulated to avoid excessive radiation. However, the radiation losses are considerable even in the best settings.

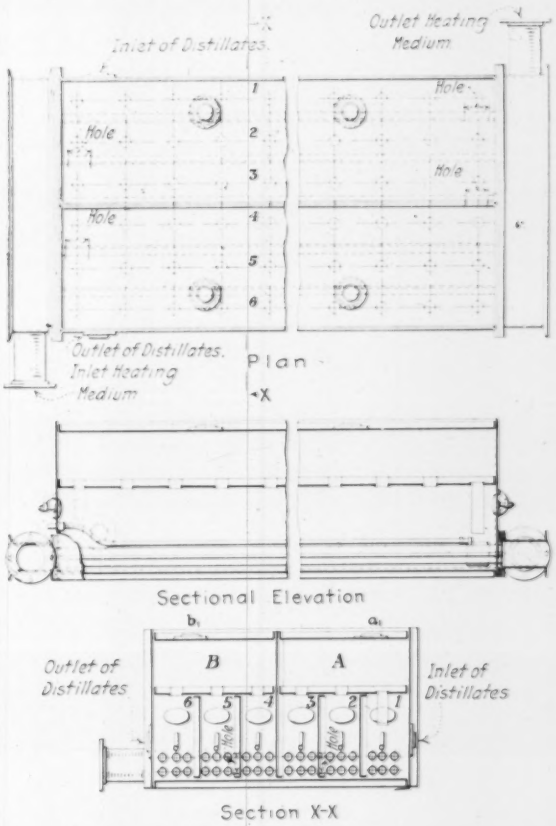


FIG. 2 SEPARATOR

The Trumble distilling apparatus is quite a departure from that used in the method described and has proved very successful in the plants where it has been installed. The principal parts of the apparatus are shown in Figs. 1, 2 and 3.

In Fig. 1 is shown a Trumble evaporator, to which in this case is connected an evaporator column. The evaporator con-

[1] Engineer, Simplex Refining Company, San Francisco, Cal.

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sists of a closed cylindrical metal shell, vertically disposed, to which heat is applied from the outside in any convenient manner, as for example, by flue gases or by vapors from another evaporator.

Inside the evaporating chamber is arranged a central vertical pipe having umbrella-shaped devices attached thereto at intervals, which are called "spreader hoods," so that oil when fed to the apex of these hoods will flow down over their sides in a thin film after the analogy of rain flowing down the outside of an umbrella. The lower edges of these hoods are at a little distance from the sides of the wall of the evaporating chamber, and in operation the oil flows down and over the hood and strikes against the interior wall of the evaporating chamber and flows down the wall in a thin continuous film. In case any of the oil should not strike against the wall in the evaporating chamber, but should drop off the edge of the hood and fall vertically; or in case there should be a tendency to bubbling or foaming on the wall of the evaporating chamber whereby a portion of the oil may be thrown back toward the center of the evaporating chamber, such oil will be caught by the next spreader hood and will flow down the surface thereof, thereby insuring an ultimate spreading of the oil on the wall of the evaporating chamber.

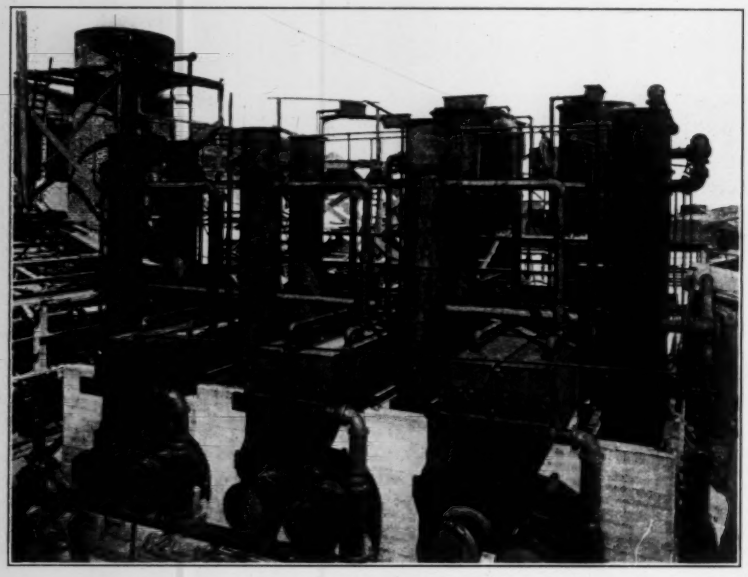

FIG. 3 GENERAL ARRANGEMENT OF PLANT

The oil to be operated on is fed through a supply pipe to the top of the evaporating chamber and discharges downward on the apex of the uppermost hood. The oil then flows down this hood in a thin stream and is delivered against the interior wall of the evaporating chamber as above described.

The centrally arranged vapor take-off pipe in the evaporating chamber, to which the spreader hoods are attached, is provided with perforations underneath each of the hoods, and through these perforations the vapors pass from the evaporating chamber into the vapor take-off pipe. Located in this vapor take-off pipe are lateral branch pipes, and these branches extend through the wall of the evaporating chamber to the outside of the apparatus.

Fig. 2 shows the construction of the separator. This is a rerun still for distillates from bottom of dephlegmators, or from any other source, if these need fractioning. The distillate flows into compartment (1) over a number of pipes through which a heating medium is passed, either residuum or vapors as the case may be, and then passes through opening at end of compartment (1) into compartment (2) and back through compartment (3), and so on, leaving at end of compartment (6). The vapors evolved in compartments (1), (2), and (3) pass through openings into vapor compartment A and out through opening a_1 to the condenser or through dephlegmator to condenser, depending upon the fractionation required. The vapors evolved in compartments (4), (5), and (6) pass into vapor compartment B and out through opening b_1, to condenser, etc.

The manifolds on the ends of the separators are provided with covers having stuffing boxes through which valves are operated to regulate the flow through tubes in each compartment, thereby controlling the heat in these compartments.

The illustrations, Figs. 3 to 6 inclusive, are from photographs taken during the construction of a plant employing the Trumble system. Fig. 3 gives a general view. In the foreground, at the left, is the pipe heater and located in the brick stack at the left is the evaporator. In the distance are the dephlegmators, in the foreground the separators and the vertical condensers for the vapors from the separators. Under the arches are the coolers for distillates. The pipe lines in the trench are the distillate lines from the condensers and coolers carrying the cooled products to the receiving boxes. The arrangement of these receiving boxes is shown in Fig. 4. Behind the boxes are dewatering traps for separating the water from the distillates. Fig. 5 shows the dephlegmators with the heat exchangers underneath. Fig. 6 shows the operating valves for the distillates from the dephlegmators. These valves as well as all operating valves are handled from one platform.

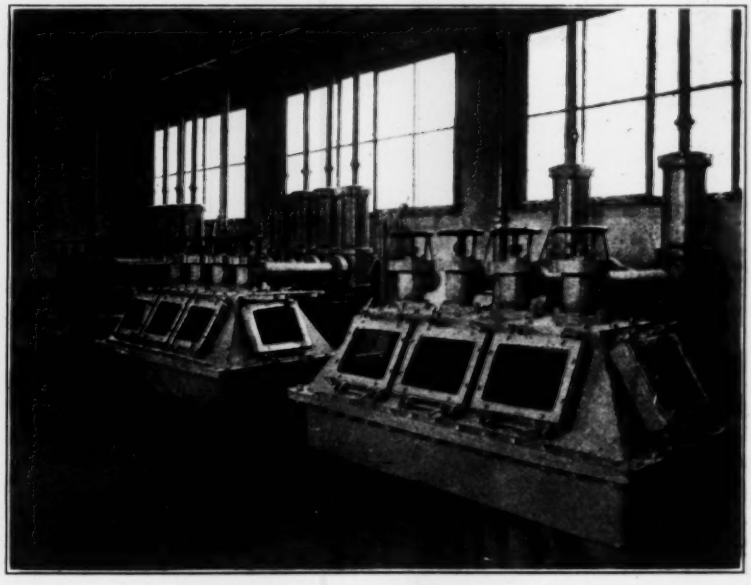

FIG. 4 ARRANGEMENT OF RECEIVING BOXES

All plants are designed to meet the conditions under which they are to be used, but they are very flexible and are able to take care of a very wide range of conditions by controlling the heat of the furnace and the velocity of the oil which runs through it. It will be impossible to go into the many different arrangements of plant design but the following will make clear the running of a typical and successful plant.

The flow of the crude oil through the plant is indicated by the flow sheet in Fig. 7. The oil enters through a 6-in. line and is used as a cooling medium in the six coolers shown. These coolers are of the horizontal tubular type, 30 in. in diameter, with sixty-two 2-in. by 18-ft. tubes. The oil enters at the bottom and passes through the tubes, making four passes, and comes out at the top and goes into a header, through which it passes into the four heat exchangers or coolers for the residuum.

These heat exchangers are 48 in. in diameter and have 178 2-in. by 18-ft. tubes. The crude oil enters the first heat exchanger at the bottom and passes through the tubes, making six passes, and out at the top into the bottom of the next exchanger, and so on, to the heater pipes, where it is split in two, each half passing in series through seventy-two 18¾-ft. lengths of 4-in. pipe, flowing back and forth and upward at all times, and then into the top of the evaporator, where it flows down the sides in a thin film.

The oil in passing through the heater pipes and evaporator is heated by the flue gases. The vapors evolved are separated in the evaporator and taken care of later. The oil is maintained at a constant level in the bottom of the evaporator and runs out of the bottom of it as residuum. A perforated steam coil is placed in the bottom of the evaporator under the liquid and superheated steam is passed through it in order to drive off any of the lighter distillates which may drop back from the vapors. However, very little steam is necessary in this case, as the heat losses are supplied by the flue gases.

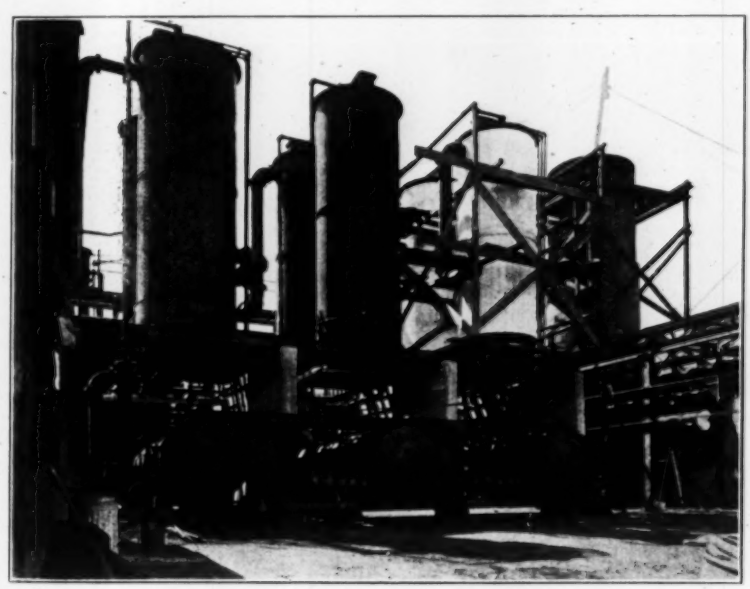

FIG. 5 DEPHLEGMATORS WITH HEAT EXCHANGERS UNDERNEATH

After leaving the evaporator the residuum is used as a heating medium for redistilling the distillates passing through the separators, and then flows through the heat exchangers countercurrent to the crude oil. The residuum enters the first heat exchanger at the top and makes two passes around the tubes and out at the bottom, then into top of the second exchanger, and so on through the five heat exchangers and through a standpipe, which is vented and which controls the head of residuum in the bottom of the evaporator, and then to the storage tanks.

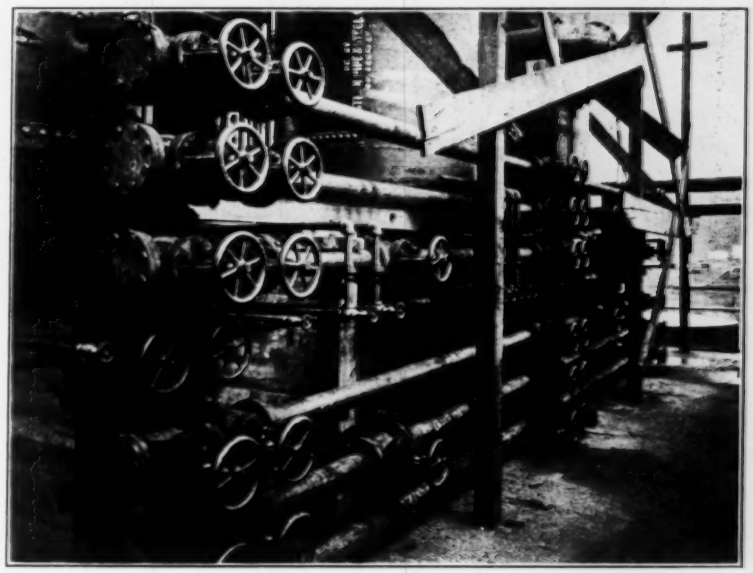

FIG 6 OPERATING VALVES FOR DISTILLATES FROM DEPHLEGMATORS

Having followed the course of the crude oil through the apparatus, showing the separation of it into vapors and residuum, it remains to dispose of the vapors shown on flow chart in Fig. 8. The vapors from the central vapor column of the evaporator are taken out through a shell and connected into a header. The vapors pass from this header through an oil catcher similar to a steam separator, the condensate passing out of the bottom of it into the bottom of the evaporator. They then pass through six large dephlegmators in series, flowing into the bottom of each and out at the top. In each dephlegmator a partial condensing of the vapor takes place, thus forming a liquid in the bottom of that particular dephlegmator. From some of the dephlegmators this condensed liquid is a ready product; from others it lies just between two different products.

A system of water circulation is used as a cooling medium for the vapors from the dephlegmators and separators. The vapors are cooled in vertical tubular condensers and about twenty barrels of water are required per barrel of distillate cooled. Superheated steam is used in the bottom of the evaporator, separators and dephlegmators as an agitator to relieve the lower boiler point fractions from the bottoms. About 30 lb. per barrel of distillate are produced.

With two Trumble plants in operation continuously for eight months, the company for whom these plants were installed has averaged a run of 16,000 barrels of crude oil per day of 24 hours through both plants, 30 per cent of this crude

oil being vaporized and fractionated into ready marketable distillate products. During this time 1.1 per cent of the total amount of crude oil run was used as fuel to do this work, and the refining losses were 0.75 per cent of the total amount of crude oil run.

Five men are required for operating the two plants per shift, i.e., one head stillman over both plants, one stillman at each plant, one fireman for both plants, and one receiving-house man for both plants.

At the present time the necessity for conserving the fuel oil and labor around an oil refinery is imperative. The whole subject is a matter of heat units and their proper conservation.

In the Trumble system the products to be re-run in the separators are condensed but not cooled, thereby saving heat. The oil is in a very thin film on the shell of the evaporator and is being heated in its downward flow. The vapors being evolved have a free relief and have no opportunity of dropping back into the residuum.

There is considerable work for the mechanical engineer in conservation of heat units around an oil refinery and in most all branches of the oil industry. There are large refineries operating today and using four to five hundred per cent more fuel than is necessary to do the work. It is possible to save, by proper distribution of the heat available around the oil refineries in the United States, at least 2 per cent of the total crude oil put through these refineries. There are large oil refineries operating to-day that are using as fuel 4 per cent of the crude oil run through them to do less work than the plant described is doing on 1.1 per cent of the crude oil run through as fuel, and the losses due to non-condensable gases, etc., are 2 per cent against 0.75 per cent.

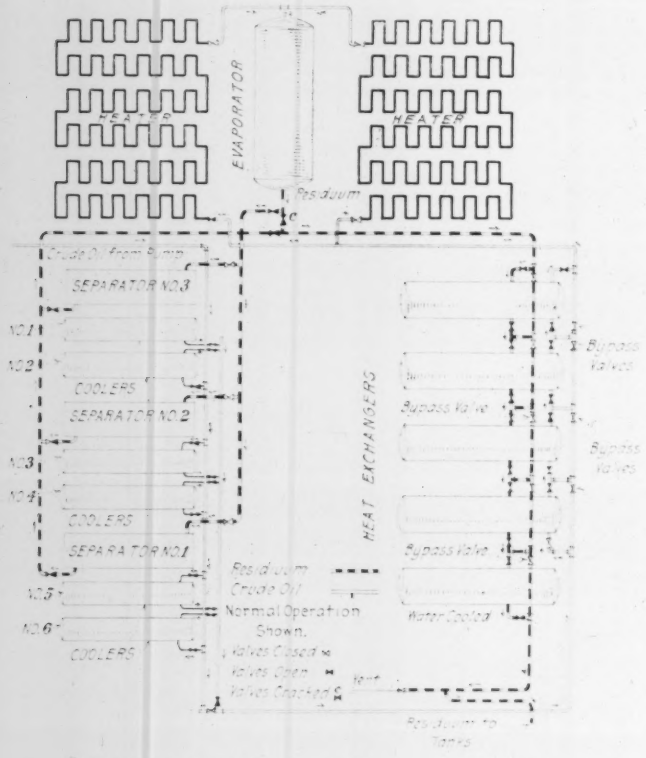

FIG 7 CRUDE OIL AND RESIDUUM SYSTEM

A typical layout such as is required for accommodating the officers and men at a National Army cantonment comprises, in round numbers, 1500 separate buildings, requiring approximately 30 million feet of lumber. Each cantonment requires a complete system of water supply and sewage disposal, the piping alone for which amounts to more than 50 miles. General warehouses, with necessary trackage, have also been provided. Where the facilities are not available in near-by cities, complete refrigerating and laundry plants have been built.

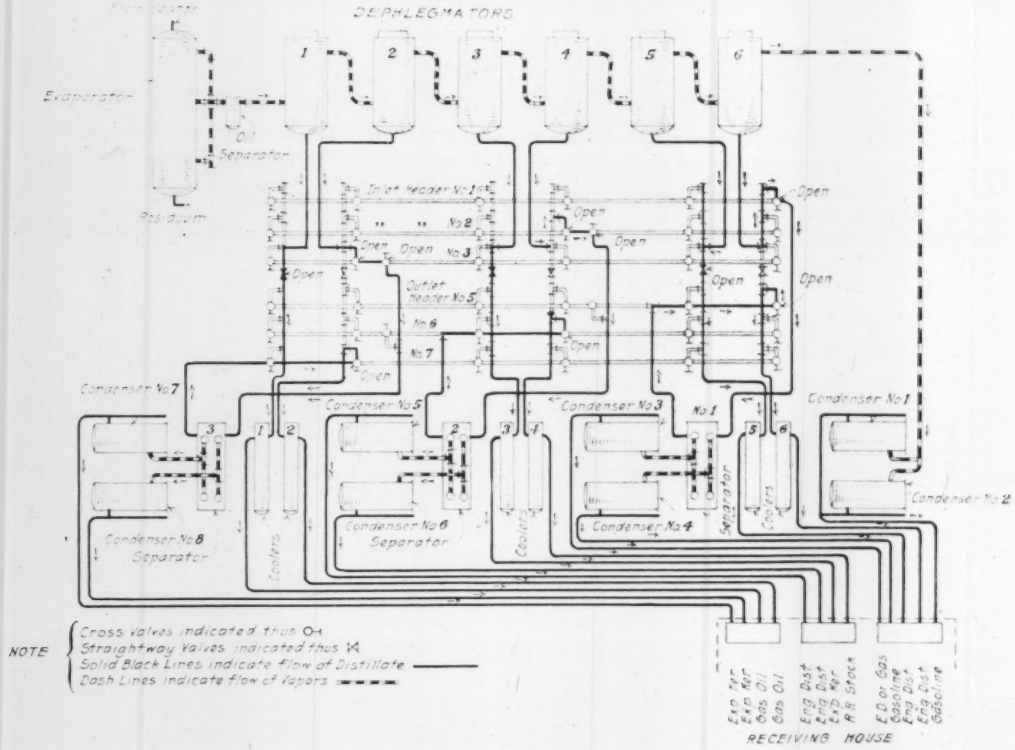

FIG. 8 VAPOR AND DISTILLATE SYSTEM

CROSS-CURRENT PREDETERMINATIONS FROM CRANK-EFFORT DIAGRAMS

A Research Study into the Cause of Excessive Cross-Current Flow Between Paralleled Alternators When Driven by Reciprocating Engines

By LOUIS ILLMER, MILFORD, CONN.

Member of the Society

WHENEVER alternating-current generators are driven by reciprocating engines, the fluctuating crank effort causes oscillatory movements to be superimposed upon the rotating armature parts. In parallel operation, such displacement movements are subject to a peculiar cumulative action, which, under adverse conditions, is liable to become so violent as to drive the armature far out of its course of uniform rotative speed. The present paper deals with the cause and effect of such cumulative action.

Acting alone, the irregular primary crank effort of the reciprocating engines accounts for but a relatively small portion of the excessive displacement movement to which the armature is subjected in parallel operation. Such small armature oscillations do, however, give rise to cross-current forces, which in turn tend to set up independent armature-displacement movements. The combined action of these two distinct periodic forces is likely to superimpose cumulative armature-displacement movements upon the rotating armature of far greater amplitude than could be produced by either component force acting alone.

The method deduced in this paper for arriving at such resultant armature-displacement increments is based upon finding the equivalent effect of the crank-effort and the cross-current-pull forces in terms of their respective sinuous sequence of force application. It will be shown that the actual crank-effort curve of any normal reciprocating engine may be approximated quite closely by means of an equivalent sine curve and that its characteristic accelerating effects may be expressed in terms of fairly simple harmonic-motion formulæ. Furthermore, the independent sinuous oscillations which the periodic cross-current pull tends to superimpose upon paralleled armatures may likewise be taken into account by formulæ of this kind.

It will further be shown that when a sinuous crank effort of a reciprocating engine works against a variable resistance, as fixed by the surging cross-current pull of the generator, the conditions become favorable for imposing cumulative oscillations upon the rotating armature and wheel parts. These parts are then alternately accelerated and retarded by the combined action of two distinct periodic forces, each of which has an independent period and each tends to set up independent armature oscillations. At times these two forces will be acting together, while at other times they will be acting in opposition, thus subjecting the armature and wheel parts to a cumulative oscillation about an imaginary position corresponding to that of uniform rotation.

The derived formulæ make possible the predetermination of the probable ultimate armature-displacement shift as measured from an imaginary reference position, for any given set of assumptions as to characteristics of generator construction, crank effort, and wheel weight. The character and maximum amplitude of the cumulative armature movements are found to depend largely upon the relation between the time period of the sinuous crank-effort curve and that of the cross-current-pull curve. Under normal conditions, the difference in period between these two curves is most readily controlled by the selection of a suitable wheel weight.

When a light wheel is used for paralleled reciprocating engines, the armatures oscillate in a relatively rapid period and the maximum cumulative armature-displacement shift is shown to be approximately twice as large as when a relatively long resultant period of oscillation is obtained by the use of a heavy wheel.

The secondary effects which accompany the use of a light wheel are more likely to upset the engine regulation and in other ways lead to detrimental electrical disturbances. In the event that the wheel weight and governor characteristics are not aptly chosen, the resulting cumulative armature oscillations may set up a heavy cross-current flow of such magnitude as to interfere seriously with the successful operation of the paralleled generators.

The subject will be treated in the following order, viz.:

a Principles underlying harmonic motion and their application in estimating initial armature displacements that result from the uneven primary crank effort of a reciprocating-engine drive

b The effect of such periodic displacement movements upon a single a.c. generator when connected to independent bus bars

c The effect of periodic armature oscillations upon paralleled generators in setting up a variable resistance against which the engine must work; discussion of the cumulative oscillations which are likely to occur whenever a variable load of this kind is driven by the fluctuating crank effort of a reciprocating engine

d Conclusions

e Appendix: Characteristic behavior of an alternating-current generator and other electrical aspects of the parallel-running problem relating especially to cross-current pull and its effects in causing periodic variations in the engine load.

INTRODUCTORY

When a reciprocating engine works against a *constant* load, the increment of flywheel displacement resulting from its uneven crank effort is dependent upon the inertia of the wheel. Its mass is alternately accelerated and retarded in proportion to the undulating character of the crank-effort forces, and for present purposes the resultant change in the wheel velocity may be taken as a convenient measure of such crank-effort irregularity.

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 4 to 7, 1917. The paper is here printed in abstract form and advance copies of the complete paper may be obtained gratis on application. All papers are subject to revision.

The average wheel velocity may be assumed to coincide with that of an imaginary wheel rotating at absolutely uniform speed, such that any velocity change induced by the variable crank effort will cause the actual wheel to lag or lead with respect to the virtual position fixed by the reference standard.

Expressed mathematically, the foot-pounds of energy absorbed in raising the flywheel velocity from V_2 to V_1 is

$$\frac{1}{2}m\,(V_1^2 - V_2^2) = m\left(\frac{V_1 + V_2}{2}\right)(V_1 - V_2) = 2\,mV_0v_0 = \triangle W_0 \ldots [1]$$

where $V_0 = (V_1 + V_2)/2$ = reference standard for uniform rotation, i.e., synchronous speed as measured by the average crankpin velocity in ft. per sec.

$v_0 = (V_1 - V_2)/2$ = maximum crankpin velocity change as measured with respect to the reference standard V_0

$2v_0/V_0 = \delta_0$ = coefficient of speed fluctuation as determined from the primary crank-effort diagram

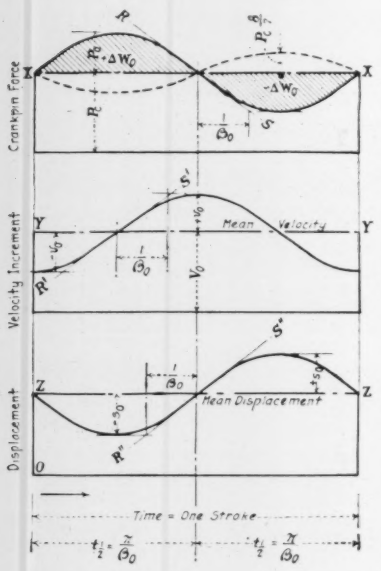

FIG. 1 SINUOUS CRANK-EFFORT DIAGRAMS

$m = \dfrac{G}{g}\left(\dfrac{\rho}{R}\right)$ = equivalent units of wheel mass transferred to the *crankpin* radius R.

$\Sigma\dfrac{G}{g}\rho^2$ = equivalent moment of inertia of the crankshaft weights, g being gravity acceleration at 32.2 ft. per sec. per sec.

G = equivalent rim weight of wheel, lb., which is equal to the weight of the rim plus about 1/10 rim weight for arm allowance, plus the armature weight as transferred to the center of gravity of the wheel rim ρ.

ΔW_0 = foot-pounds of fluctuating energy as measured by one-half the total lobe areas enclosed by the crank-effort diagram per stroke

Assuming a reciprocating engine to work with a sinuous crank effort, the phase relation between the velocity change and displacement increment which it imparts to the wheel is shown in Fig. 1. The common abscissa is taken on a time basis which is proportional to the travel of the crankpin.

The upper sine curve represents the variable crank-effort force drawn about the base line XX, which ordinate represents the mean turning force P_c acting normal to the crankpin radius. The sectional area $\pm\Delta W_0$ denotes the fluctuating energy that must be successively taken up and given out by the flywheel parts in order to equalize the sinuous crank effort.

The resulting velocity change as measured at the crankpin is indicated by the sinuous line superimposed upon the mean or synchronous velocity base YY. The sequence of the displacement increments is indicated by the lower sine curve plotted with respect to the base line ZZ, which represents the reference position assumed by the crankpin when rotating at the uniform synchronous speed V_0.

Restricting the interplay of the fluctuating energy ΔW_0 to that exchanged during any one stroke period of the engine, the coefficient of energy fluctuation becomes equal to

$$K = \triangle W_0/W_0 \ldots [2]$$

where

K = coefficient of energy fluctuation, which is also equal to one-half the mean ordinate of the lobe area ΔW_0 divided by mean turning effort P_c

$W_0 = P_c \times \pi R$ = foot-pounds of effective work done per stroke, i.e., mean engine turning effort P_c multiplied by the crankpin path during one stroke

P_c = b.hp. $\times$ 550/V_0 = average crankpin force (in lb.) acting normal to the crankpin radius R, measured in feet.

HARMONIC-MOTION FORMULÆ

A sinuous crank effort, as measured with respect to the mean axis XX of Fig. 1, sets up a change in the synchronous velocity of the rotating-wheel parts within the limits $V_0 - v_0$ and $V_0 + v_0$, in accordance with the law of simple harmonic motion. The principles underlying such motion are easily established since the average ordinate of the sine-lobe area ΔW_0 bears a simple fixed relation to the maximum accelerating force P_0.[1]

[1] Starting with the general equation for accelerated motion,

$$a_0 = P_0/m \ldots [3]$$

where

a_0 = maximum acceleration acting upon the mass m as measured in ft. per sec. per sec.

P_0 = maximum accelerating force in pounds, as measured at the middle of the sinuous crank-effort lobe.

Since the average ordinate under the sectioned sine lobe $\triangle W_0$ is equal to $(2/\pi)\,P_0$, the maximum velocity increment will be

$$v_0 = (2/\pi)\,a_0t_m \ldots [4]$$

where

t_m = time equivalent one-half length of the sine lobe as measured in seconds, which in angular measure corresponds to $\pi/2$ radians.

The resulting maximum displacement being proportional to the average velocity change multiplied by time, it follows that

$$s_0 = (2/\pi)\,v_0t_m = (2/\pi)^2\,a_0t_m^2 \ldots [5]$$

where

s_0 = maximum linear displacement or amplitude of oscillation (in ft.) resulting from a sinuous velocity change whose maximum is v_0.

As a further condition for simple harmonic motion, the maximum acceleration a_0 must be directly proportional to the displacement s_0, which expressed mathematically takes the convenient form

$$a_0 = \beta_0^2 s_0 \ldots [6]$$

where

β_0^2 = specific acceleration of the sinuous crank effort at unit displacement, as measured with respect to the synchronous reference position ZZ of Fig. 1.

For the critical value $s_0 = 1$ ft., the factor a_0 becomes equal to β_0^2; substituting this value in [5] and transposing, the following relation is obtained, which shows that the time period for harmonic motion is independent of its amplitude; thus,

$$t_m = \pi/2\beta_0; \quad t_n = \pi/\beta_0; \quad t_t = 2\pi/\beta_0 \ldots\ldots\ldots\ldots\ldots\ldots [7]$$

where t_m, t_n and t_t are the respective times of a quarter, half and complete period of harmonic oscillation.

It will be seen that the constant β_0 converts the time factor into angular or π measure. It also fixes other important characteristics of simple harmonic motion, as is evident from the following substitution in Equation [4], viz.

$$v_0 = (2/\pi)\, a_0\, (\pi/2\beta_0) = a_0/\beta_0 = \beta_0 s_0 \ldots\ldots\ldots\ldots\ldots\ldots [8]$$

When a body oscillates harmonically, the characteristic relations existing between the acceleration, velocity and displacement factors are definitely fixed by the basic constant β_0 as given in Equation [8].

Applying these deductions to the case of a sinuous crank-effort diagram for a single-cylinder engine, the time period of a complete oscillation is that required for one stroke, which is equal to

$$t_1 = 60/2N = 2\pi/\beta_0 \ldots\ldots\ldots\ldots\ldots\ldots [9]$$

where N = revolutions per minute.

The corresponding basic value of the primary crank-effort constant β_0 may be found by substituting the above value of t_1 in Equation [7]; thus,

$$\beta_0 = 2\pi/(30/N) = 0.21\, N \ldots\ldots\ldots\ldots\ldots\ldots [10]$$

The other basic values required to characterize the harmonic wheel motion set up by a sinuous crank effort when making a complete oscillation in a time period of one stroke as per

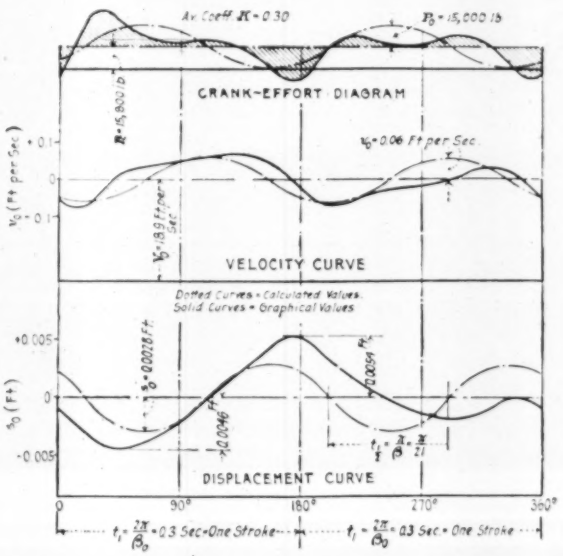

FIG. 2 CRANK-EFFORT DIAGRAMS FOR SINGLE-CYLINDER 500-B.HP. KOERTING GAS ENGINE

Cylinder dimensions, 25 × 43⅜ in., speed, 100 r.p.m.; piston-rod diameter 6½ in.; wheel weight at 17½ ft. outside diameter, 24,000 lb.; equivalent mass m at crankpin, 12,000 units; load condition, maximum.

Eq. [9], may be found by substituting in Eq. [1]; thus,

$$v_0 = \triangle W_0/2\, mV_0 = \beta_0 s_0 \ldots\ldots\ldots\ldots\ldots\ldots [11]$$

where $V_0 = 2\pi RN/60$ = mean crankpin velocity in ft. per sec.

v_0 = maximum velocity increment superimposed upon V_0

s_0 = corresponding maximum displacement (in ft.) as measured from the synchronous reference position ZZ.

For a single-cylinder engine the pitch length of its crank-effort lobe, i.e., the space passed over by the crankpin in the time period of one-half stroke, is equal to $\pi V_0/\beta_0$, and since $(2/\pi)P_0$ represents the average accelerating force acting upon the crankpin during this period, then

$$\triangle W_0 = \frac{2}{\pi} P_0 \left(V_0 \frac{\pi}{\beta_0} \right) = \frac{2\, P_0 V_0}{\beta_0} = 2\, mV_0 v_0 \ldots\ldots\ldots [12]$$

In a similar manner it will also be found that

$$\triangle W_0 = KW_0 = KP_c V_0\, (2\pi/\beta_0) \ldots\ldots\ldots [13]$$

For a single-cylinder engine the maximum velocity increment v_0 may be found in terms of known constants by substituting the above values in Eq. [11]; thus,

$$v_0 = \frac{2\pi K P_c V_0}{\beta_0} \cdot \frac{1}{2mV_c} = \frac{\pi K P_c}{m\beta_0} = \beta_0 s_0 \ldots\ldots\ldots [14]$$

From the above it also follows that

$$P_0 = m\beta_c^2 s_0 = \pi K P_c \ldots\ldots\ldots [15]$$

Fig. 2 shows that the average results obtained graphically from an actual single-cylinder crank-effort diagram can readily be evaluated on the basis of the sine-curve approxi-

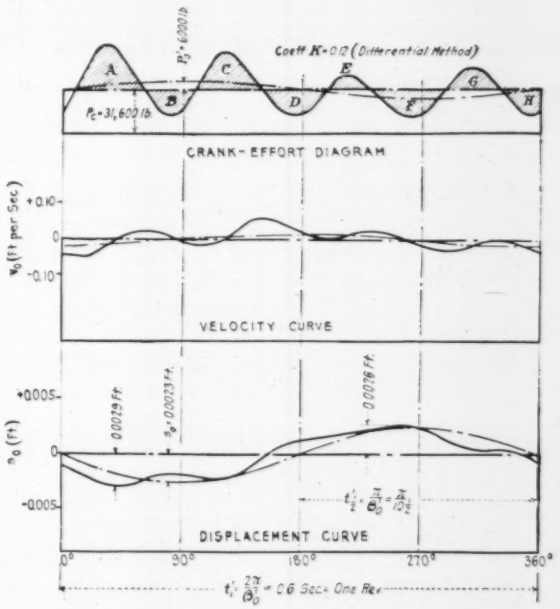

FIG. 3 CRANK-EFFORT DIAGRAMS FOR TWIN-CYLINDER 2 x 500-B.HP. KOERTING GAS ENGINE

Cylinder dimensions, 25 × 43⅜ in.; wheel weight at 17½ ft. outside diameter, 48,000 lb.; equivalent mass m at crankpin, 24,000 units; load conditions, maximum

mation, and that the resulting average velocity and displacement increments may be determined with a fair degree of accuracy by means of the given equations. This figure represents a crank-effort diagram for a single-cylinder 500-b.hp. double-acting Koerting gas engine operating at maximum load.

A corresponding diagram for a set of twin-cylinder engines of the same make and size is shown in Fig. 3. In both diagrams due allowance has been made for the inertia effect of the reciprocating parts, angularity of connecting rod, and the like.

ARMATURE-DISPLACEMENT INCREMENTS FOR SINGLE NON-PARALLELED GENERATOR UNITS

It is to be borne in mind that the harmonic-motion formulæ thus far deduced apply only to the case of a reciprocating engine whose sinuous crank effort works against a *uniform* or straight-line resistance XX, such as would be encountered in a lineshaft drive and the like.

These simple relations may be materially modified when reciprocating engines are used to drive alternating-current generators, especially those connected in parallel. In that event the armature oscillations resulting from the irregular crank effort set up a periodic cross-current pull which is capable of producing a cyclic variation in the engine load. This reactive effect is dependent upon the characteristic behavior of the driven a.c. generator, the essential features of which are best represented graphically by means of vector diagrams as elucidated in the Appendix included in the full paper.

Touching upon the principles underlying electric-power generation by means of an alternator, it may be pointed out that such a generator running at synchronous speed can only deliver current to the bus bars when the armature is made to lead with respect to the neutral position assumed by the armature when running at no load. That is to say, the application of engine power forces the armature ahead of this neutral phase position by a certain angular displacement lead such that it will still be running at synchronous speed but out of phase with its neutral phase position by an angular displacement lead $+\alpha_0$, on the other hand, when an external resisting force causes the armature to lag with respect to the neutral phase position by an angle $-\alpha_0$, this reverse action will convert the machine into a synchronous motor.

TABLE 1 COMPARATIVE DISPLACEMENT VALUES FOR SINGLE ENGINE

Items	Estimated by Formulæ	Graphical Determinations
P_c	15,800 lb.	
β_0	21	
K	0.30	0.24 to 0.39
P_0	15,000 lb.	10,000 to 27,000 lb.
$\triangle W_0$	27,000 ft-lb.	20,400 to 33,200 ft-lb.
$(2\pi)s_0$ (avg. velocity)	0.038 ft. per sec.	0.041 ft. per sec.
$(2\pi)s_0$ (avg. displacement)	0.0018 ft.	0.0021 ft.

As explained in the Appendix, the mean angular displacement lead α_0 is dependent upon the construction characteristics of the alternator and serves as a measure of the full-load output delivered by this type of generator. Assuming the driving torque and output to remain constant, then the uniformly rotating armature will maintain a constant lead angle α_0 with respect to its neutral or no-load phase position. In case, however, the generator is driven by a reciprocating engine, its irregular crank effort will cause a periodic shift in the armature displacement equal to $\pm\alpha_x$, as measured with reference to the mean lead angle α_0.

Applying these deductions to the case of a *single* alternating generator driven by a reciprocating engine, the resulting speed fluctuation as measured by the coefficient δ_0 will cause the armature lead angle to vary within the limits $\pm \frac{1}{2}\delta_0\alpha_x$. This periodic shift in the armature lead angle α_0 serves to produce a corresponding change in the generator output. Hence the effect of varying the resistance against which the engine has to work may be embodied in its crank-effort diagram by substituting a sinuous curve for the straight base line XX of Fig. 1. As shown dotted, the phase and period of this new resistance curve for a single-cylinder unit coincide with those of its primary displacement curve, while the amplitude of such initial armature oscillation may be fixed at $\frac{1}{2}\delta_0 P_c$, as plotted upon the reference line XX.

CUMULATIVE DISPLACEMENT EFFECTS FOR PARALLELED GENERATOR UNITS

Turning now to the electrical conditions under which alternators operate in parallel, such armatures are no longer locked with the external circuit in the manner of a single generator; instead, the electrical tie assumes characteristics closely analogous to those of a flexible coupling between the two paralleled armature shafts, all of which is rather fully set forth in the Appendix.

The flexible nature of this coupling allows one of the paralleled armatures to lead periodically with respect to its mean lead angle α_0, provided the other armature simultaneously lags with respect to its α_0 by an approximately equal angular displacement shift α_x. This difference in armature positions sets up an equalizing or cross-current flow between the generators whereby the lagging armature may momentarily generate less power than its mate without materially affecting the combined output delivered to the common bus bars.

The cross-current pull is, however, capable of superimposing oscillations of considerable magnitude upon the rotating armature. The amplitude of such oscillations is generally much larger than was found to be the case for the single generator connected to independent bus bars.

It will now be shown that this increment of displacement is due to the cumulative action which results in parallel generators whenever the variable generator load, as fixed by the periodic cross-current pull, is combined with an uneven sinuous crank effort having a different period.

The resultant periodic armature oscillation produced by the combined action of two such forces, i.e., excess crank effort P_x and cross-current pull P_{cc}, is likely to become cumulative when the period of the pull P_{cc} bears certain critical relations to the period of the force P_x.

As given by Eq. [A] of the Appendix, the factor P_{cc} as taken in terms of the mean crankpin force P_c is equal to

$$P_{cc} = P_c(\sin\alpha_x \sin\alpha_0)\cos\alpha_0$$

Owing to the relatively small angular armature displacements permissible in good practice, the mathematical treatment of this portion of the discussion may be much simplified by substituting angular measure for the sine values of the lead and shift angles α_0 and α_x, and by further assuming that the value of $\cos\alpha_0$ in the above equation may be taken as equal to unity without serious error. On the basis of this approximation, Eq. [A] reads

$$P_{cc}/P_x = \alpha_x/\alpha_0 = s_x/s_0$$

or

$$P_{cc}/s_x = P_c/s_0 = F = m\beta_x^2 \qquad [16]$$

where α_0 = mean angular displacement lead of the armature as measured in electrical radians

α_x = angular displacement shift of the armature as measured with respect to mean lead position α_0

$s = \alpha_0 R$ = arc length in feet, corresponding to the armature-displacement lead angle α_0 as measured at the crankpin circle

$s_x = \alpha_x R$ = arc length in feet, corresponding to the armature-displacement shift angle α_x.

In the above equation the constant F represents the specific accelerating force (in lb.) of the cross-current pull when the linear displacement $s_x = 1$ ft., as measured at the crankpin circle. Eq. [16] further shows that the cross-current pull P_{cc} may be taken as directly proportional to the linear shift s_x

and that it becomes approximately equal to the mean engine turning force P_e when $s_x = s_a$. The constant β_x fixes all of the characteristic relations of the harmonic armature movements resulting from the action of the cross-current pull except that of the amplitude limit.

Since the angles α_0 and α_x are measured in electrical radians, Eq. [16] may also take the form

$$\frac{F}{m} = \beta_x^2 = \frac{P_c}{m} \cdot \frac{n}{Ra_0} \qquad [17]$$

where β_x^2 = specific acceleration of the cross-current pull at s_x = 1 ft. linear armature displacement as measured at the crankpin circle

$\pi R/n$ = generator pole pitch as measured (in ft.) at the crankpin circle = π electrical radians.

n = number of pole pairs = cycles per sec. $\times (60/N)$.

The resulting cross-current pull corresponding to a given armature shift s_x is dependent upon the constructive characteristics of the generator, which are largely fixed by the

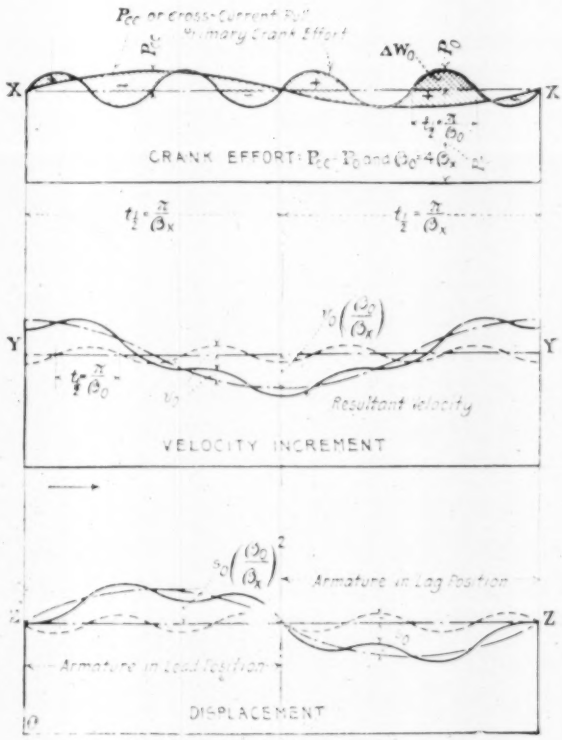

FIG. 4 DIAGRAM SHOWING CUMULATIVE EFFECT OF CROSS-CURRENT PULL FOR $\beta_0/\beta_x > 7/2$

value of s_a. Accordingly, the relation of the basic constants β_0 to β_x may also be expected to be dependent upon the factor sx. For single-cylinder engines the numerical value for this relation may be arrived at as follows:

Transposing Eq. [14] to the form $\beta_0^2 = \pi K P_c \, ms_a$ and dividing by Eq. [17], gives

$$\frac{\beta_0}{\beta_x} = \sqrt{\frac{(\pi K/s_0)}{(n/Ra_0)}} = \sqrt{\pi K \frac{s_a}{s_0}} = 0.21\,N\sqrt{\frac{Ra_0}{n} \cdot \frac{m}{P_c}} \qquad [18]$$

When $\beta_0' = \frac{1}{2}\beta_0$, the corresponding equation for twin-cylinder engines becomes equal to

$$\frac{\beta_0'}{\beta_x} = 0.105\,N\sqrt{\frac{Ra_0}{n} \cdot \frac{m}{P_c}} \qquad [18a]$$

The above equations fix the vital relations required for cross-current determinations in paralleled generators: they show that the important ratio of the constants β_0/β_x is independent of the coefficient K, and secondly that this ratio is largely dependent upon the speed factor N.

Since the value of the primary displacement s_0 is usually quite small in comparison with s_a, the period of oscillation set up by the cross-current pull when acting alone is a relatively long one, being equal to

$$t_{\frac{1}{2}} = \pi/\beta_x \qquad [19]$$

It will be seen that the paralleled armatures are acted upon by two distinct periodic forces, i.e., excess crank effort and cross-current pull, whose time periods are π/β_0 and π/β_x, respectively. Each of these forces tends to set up independent oscillations, but they combine to swing the armatures in a

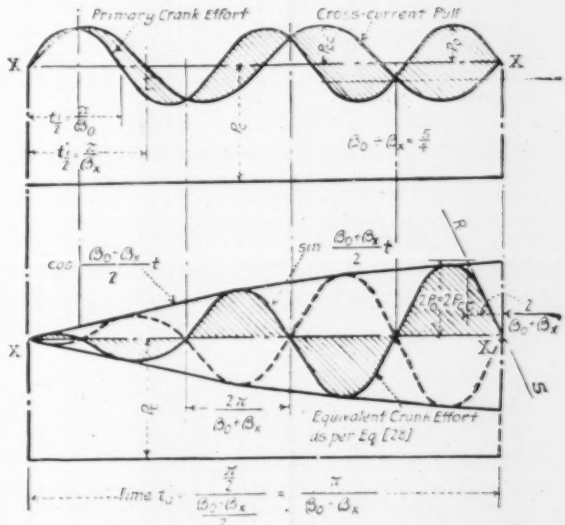

FIG. 5 DIAGRAM SHOWING CUMULATIVE EFFECT OF CROSS-CURRENT PULL FOR $\beta_0/\beta_x > 7/2$

resultant period which may be found by replacing the straight resistance line XX of the crank-effort diagram by a sinuous resistance or load curve having a relatively large amplitude equal to the cross-current pull P_{cc}, as indicated in Fig. 4.

In the case of paralleled generators, the resultant sectioned lobe area of the crank-effort diagram is to be taken with respect to the resultant sinuous resistance line P_{cc}, since this area fixes the period and generally determines the character of the final armature movements.

The cross-current pull will continue to superimpose cumulative oscillations upon the rotating armature, until the condition of indifferent equilibrium is finally reached where $P_{cc} = P_c$.

The consideration of this problem may be further simplified by taking into account only the two limiting conditions as to time of oscillation: namely, (1) the case in which the ratio of β_0/β_x is a relatively large one, i.e., 7/2 or over, by which assumption the period and amplitude of the cross-current pull is made to dominate and fix the character of the resulting armature movements as shown in Fig. 4; and (2) the case in which the factors β_0 and β_x are approximately equal, the effect of which is to produce a series of comparatively rapid armature oscillations, whose amplitude rises and falls periodically in accordance with the sine law, as indicated in Fig. 5.

CASE I CUMULATIVE ARMATURE DISPLACEMENTS FOR (β_0/β_x) 7/2

Taking up the first of these cases in detail and referring to Fig. 4, the average velocity change produced upon the armature and wheel parts will be a function of the resultant sectioned area lying between the crank-effort and the sinuous resistance or load curves. For the condition that $P_{cc} = P_0$, it will be apparent that the total area under one of the cross-current or P_{cc} sine lobes as measured with respect to its straight base line XX becomes equal to $(\beta_0/\beta_x)\Delta W_0$, i.e., equal to the sum of all the ΔW_0 lobe area enclosed by the primary crank-effort curve in the time period π/β_x. If then such a cross-current pull were acting alone upon the armature parts, the energy absorbed during the time period π $2\beta_x$ would, according to Eq. [4], impart a maximum velocity change equal to $(\beta_0/\beta_x)v_0$. This value serves to fix the amplitude of the fundamental velocity curve shown dotted and dashed in Fig. 4.

The cross-current pull when acting alone may be expected to set up armature oscillations closely following the laws of simple harmonic motion, because the accelerating force P_{cc} is approximately proportional to the displacement shift s_x. In addition to this motion, the irregularity of the crank effort sets up independent sinuous velocity changes of smaller magnitude as drawn dotted upon the axis YY, which superimposed upon the fundamental curve produces the resultant velocity shown by the full-lined curve of Fig. 4.

The corresponding maximum linear armature-displacement shift resulting from the combined action of the cross-current pull and irregularity of crank effort, becomes equal to

$$s_x = v_x/\beta_x = s_0(\beta/\beta_x)^2[1 + (\beta_x/\beta_0)] \quad \ldots\ldots [20]$$

by Eq. [18] $= \pi K s_0[1 + (\beta_x/\beta_0)]$ for a single-cylinder engine.

Equation [20] fixes the actual limiting displacement shift s_x that may be expected when two paralleled alternators have settled into equilibrium as regards the interchange of cross-current energy.

The corresponding mean shift angle α_{xav} measured with respect to α_0 becomes approximately equal to

$$\pm\ \alpha_{xav} = \frac{2}{\pi}\frac{s_0}{R}\left(\frac{\beta_0}{\beta_x}\right)^2\left(1 + \frac{\beta_x}{\beta_0}\right) = \frac{2}{\pi}\alpha_x\left(1 + \frac{\beta_x}{\beta_0}\right) \quad \ldots\ldots [21]$$

This angle α_{xav} is fixed by the average ordinate of the sectioned area lying between the crank effort and the sinuous load curve as indicated in Fig. 4.

The correctness of the above deductions has been checked by means of actual cross-current measurement tests conducted upon a set of single-cylinder 500-b.hp. Koerting gas engines having heavy flywheels and driving three-phase alternators on an induction-motor load.

The crank-effort diagram for these engines is almost identical with that given in Fig. 2. The comparative results attained with these two similar units, running at a practically constant load, are given in Table 2.

The pulsations recorded by the ammeter readings, as measured from maximum to maximum, showed 35 to 38 beats per min. as against an estimated period for such beats of $2\pi/\beta_x = 1.9$ sec., or about 32 beats per min.

CASE II CUMULATIVE DISPLACEMENTS FOR $(\beta_0/\beta_x) < 7/2$

The foregoing formulæ for the displacement shift angle α_x were based upon the condition that the ratio β_0/β_x shall not fall below the critical value 7/2. At this juncture the time periods of the crank-effort and of the generator-load curves become more nearly equal, and as a result the combined or resulting sectional area lying between these curves assumes an essentially different character from that shown in Fig. 4. The armature movements which take place when the ratio of β_0/β_x is relatively small are still found to act cumulatively until the cross-current pull p_{cc} reaches its critical value P_0, but the effect produced is a series of rather rapid armature oscillations which periodically rise and fall in amplitude as indicated in Fig. 5. In order that such armature movements may occur without giving up energy to the external power circuit, one of the paralleled armatures must lead at approximately the same instant that its mate lags, in the manner shown respectively by the full- and dotted-lined oscillations in the lower crank-effort diagram.

The equation for any ordinate P_x of the sectional area lying

TABLE 2 COMPARATIVE VALUES FOR SINGLE-CYLINDER ENGINES
$(\beta_0/\beta_x = 6.4)$

SPECIFICATIONS	
Type of engine	Double-acting two-stroke Koerting gas-engine without tail rod
Cylinder dimensions	25 x 43⅜ in.; speed, 100 r.p.m.
Average engine load	425 b.hp. (about)
Piston-rod diameter	6½ in.
Weight of flywheel	73,000 lb. at 18 ft. O. D.
Total mass m	38,600 units at R = 1.8 ft.
Coefficient δ_0	1/660
P_0 at K = 0.30	11,700 lb. = 0.95 P_c
Cos ϕ_0 in external circuit	0.73 (about)
Lead angle α_0	14½° (about) = 0.255 elec. radian
n at 25 cycles per sec.	15 pole pairs
RESULTS	
Displacement s_0 by Eq. [14]	0.00068 ft.
β_x by Eq. [18]	3.3 for β_0 = 21
Ratio β_0 to β_x	6.4
Displacement shift s_x by Eq. [20]	48 s_0 (about)
Shift angle α_{xav} by Eq. [21]	0.7 α_0
Ratio Z by Eq. [C]	1.08
Same by test measurement	1.065
Cross-current I_{cc} by Eq. [B]	0.51 I_0

in the upper crank-effort diagram of Fig. 5 takes the following form:

$$P_x = P_0(\sin\beta_x t + \sin\beta_0 t) \quad \ldots\ldots [22]$$

Combining the factors of this equation on the basis of the trigonometrical relation for the sum of sine values,

$$P_x = 2P_0\left(\sin\frac{\beta_0 + \beta_x}{2}\cos\frac{\beta_0 - \beta_x}{2}t\right) \quad \ldots\ldots [23]$$

This equation, as graphically analyzed in the lower crank-effort diagram, shows that the component oscillations as fixed by the sine factor vibrate cumulatively within the limit line fixed by the cosine factor. The time period of the component oscillation is determined by the mean value of β_0 and β_x, while the period of the limit line is fixed by their difference. The characteristics of the resulting velocity and displacement curves will be identical with those of the equivalent crank-effort curve shown in the lower diagram.

The time required for the cumulative oscillations to change from minimum to maximum amplitude is equal to

$$t_a = \pi/(\beta_0 - \beta_x) \quad \ldots\ldots [24]$$

which holds good for all values of β_0/β_x less than 3 and greater than unity. The maximum velocity increment attained by the wheel parts due to the accumulation of energy cannot

at any time exceed the energy equivalent of the sectioned area as fixed by the largest one of the sin $\frac{1}{2}(\beta_0 + \beta_x)$ lobes, shown in Fig. 5. The corresponding maximum acceleration is limited to $2P_0/m$, and since the resulting velocity is proportional to $1/(\beta_0 + \beta_x)$ and not to $1/(\beta_0 - \beta_x)$, it will be seen that even for long periods that accompany small differences of β_0 and β_x the cumulative energy does not under any conditions tend to produce an infinite armature deflection. This point is brought out because Bonte,[1] among others, has advanced contrary views as based upon the Rosenberg theory previously discussed.

For the cumulative oscillatory movements indicated by Fig. 5 the maximum angular displacement shift cannot exceed

$$\alpha_x' = \frac{2P_0}{P_c}\alpha_0 = \frac{2P_0}{P}\cdot\frac{s a n}{K} \qquad [25]$$

$$\alpha_{x\,av}' = \frac{2P_0}{P_c}\alpha_0\left(\frac{2}{\pi}\right)^2 = \frac{2}{\pi}\left(\frac{\alpha_x'}{2}\right)\frac{4}{\pi} \qquad [26]$$

The deductions embodied in the last two equations have been checked by the graphical determinations shown in Fig. 6, as based upon the assumed specifications noted below. These curves were kindly worked out for the author some years ago by Mr. Erich C. Rassbach. At that time the present mathematical basis had not yet been developed, and in order to determine the probable course of the resultant armature oscillations for small values of β_0/β_x, it became necessary to resort to a tedious graphical solution. The comparative figures given in Table 3 show satisfactory agreement.

The principles underlying the formulæ herein developed may also be used in solving the more general problems relating to cumulative oscillatory movements, such as are involved in hunting rotary converters and the like.

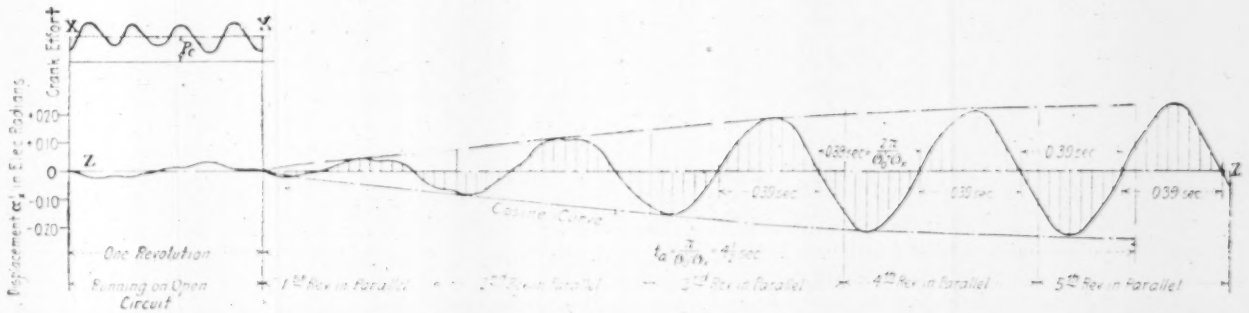

FIG. 6 GRAPHICAL DETERMINATION OF CUMULATIVE ARMATURE OSCILLATIONS FOR $\beta_0/\beta_x = 1.09$

The measured cross-current flow is determined by the average armature-displacement shift, and while α_x' for Case II is approximately twice as large as α_x as found for Case I, the average shift is almost identical with that given by Eq. [21], as is evident from the following relation:

TABLE 3 COMPARATIVE VALUES FOR TWIN ENGINES ($\beta_0/\beta_x = 1.09$)

ASSUMED SPECIFICATIONS	
Type of engine	Twin-cylinder double-acting two-stroke gas engine with tail rod
Cylinder dimensions	38 x 66 in.; speed, 80 r.p.m.
Piston-rod diameter	10 in.
Assumed load	4000 b.hp. = max. capacity
Moment of inertia of wheel	$\frac{113{,}000 \text{ lb.}}{32} \times 9.65 \text{ ft.}^2$
Total mass m	43,500 units at R = 2.75 ft.
K' by differential method	0.072
P_0 from crank-effort curve	48,000 lb. = 0.48 P_c
Lead angle α_0	about 16½° = 0.29 elec. radian
n	20 pole pairs
β_0'	0.105 N = 8.4

RESULTS	Calculated by Formulæ	Graphical Determinations
$(2/\pi)\ v_0'$ when $K' = 0.072$	0.02 ft. per sec.	0.026 ft. per sec.
$(2/\pi)\ s_0'$ when $K' = 0.072$	0.0027 ft.	0.0022 ft.
β_x by Eq. [18a]	7.7 = $\beta_0'/1.09$	.....
$\pi/(\beta_0' - \beta_x)$ by Eq. [24]	4½ sec. = 6 rev.	about 5½ rev.
Angle α_x' by Eq. [25]	0.96 α_0	About 0.85 α_0
Angle $\alpha_{x\,av}'$ by Eq. [26]	0.37 α_0	.....
Displacement shift s_x'	About 9 s_0'	About 8 s_0'
$2\pi/(\beta_0' + \beta_x)$	0.39 sec.	0.39 sec.

[1] Zeitschrift des Vereines Deutscher Ingenieure, Aug. 25, 1906, p. 1365.

CONCLUSIONS

On the basis of the principles enunciated, it may be concluded that when two alternators are thrown into parallel the resulting cross-current flow, as measured by means of ammeters, will be largely independent of the wheel weight used, except in so far as this weight may influence the character of the regulation rendered by the governor.

The difficulty that may be involved in the use of a light flywheel resides in the detrimental secondary effects that may arise. When the ratio of β_0/β_x is less than 7/2, as is likely to be the case when using a light wheel, the oscillatory peak movement indicated in Fig. 5 becomes about twice as large as would be produced by the use of a heavy wheel operating under conditions represented by Fig. 4. This difference in maximum angular displacement shift may become so marked that the armature working with a relatively light wheel may be thrown far over into the negative or motor position. Such excessive shift in the armature displacement may readily create serious electrical disturbance, for should the angle α_x' plus α_0 at any time exceed $\pi/2$ electrical radians, i.e., one-half pole pitch, the paralleled generators would immediately fall out of step.

The best results in parallel operation may, therefore, be expected when the ratio β_0/β_x is kept as high as 6 or possibly 8. As is evident from Eq. [18] and [18a], this condition is more readily complied with in the smaller short-stroke engines running at a relatively high speed. However, in order to avoid excessively heavy wheels for the long-stroke, slow-speed engines, it is found advisable to keep the wheel weight in a constant relation to the engine output.

The foregoing deductions do not take into account any beneficial effects which dampening coils and like devices may be able to exert upon the cumulative armature oscillations. The purpose of the present investigation was simply to find

the most favorable inherent conditions when operating without compensating adjuncts of any kind.

The formulæ given are further conditioned upon identical constructive characteristics for all the paralleled engine and generator units. Any important difference in this respect may involve a considerable increase in the minimum expected cross-current flow as fixed by the given formulæ.

Finally, attention is called to the need of properly selecting the coefficient of speed fluctuation for the engine governor. The extent to which the primary speed coefficient may be increased by the cumulative displacements arising in paralleled engine units is indicated by the ratio of s_x/s_0 as given in Tables 2 and 3. The governor characteristics should be such that this increased "factor of irregularity" will not throw the governor gear into resonant oscillation with the cumulative wheel period.

The use of additional wheel weight is able to effect an important change in the period of the cumulative wheel swing, and this, in turn, may make it far easier to meet the governing requirements. On the whole, therefore, it may be concluded that owing to the beneficial secondary effects the most satisfactory results in the parallel operation of reciprocating-engine units are to be attained by the use of reasonably heavy flywheels, as prescribed.

The author desires to express his indebtedness to Prof. C. D. Albert, of Cornell University, for reviewing the manuscript of this paper and for the helpful criticisms which he has made.

In marked contrast with the ordinary formal official report, the chapter on fuels and mechanical-equipment investigations in the year book of the Bureau of Mines (Department of the Interior) is of readable interest and practicable value to all concerned in fuel economy and conservation. It is stated that last year 500,000,000 tons of coal was burned, but of this amount the bureau estimates fully 125,000,000 tons, or 25 per cent, was wasted through incomplete combustion and other preventable waste. The function of the Bureau of Mines and the results obtained through its extensive investigations are also set forth in the publication.

A cobalt-chrome-carbon steel is now being made by a Sheffield works, for which it is stated that the property of red-hardness is obtained without the addition of tungsten. This steel is said to melt at lower temperatures than tungsten high-speed steel, and to be so fluid as to be readily cast into intricate forms for milling cutters, gages and similar products. It may also be annealed in the usual manner to a sufficient degree of softness to be readily machined, and can be forged without difficulty. It can be hardened by heating to 1000 deg. cent. and cooling in still air without an air blast.—*The Ironmonger*, August 11, 1917.

Before means can be found to reduce smoke, it is obvious that the causes of its production must be understood. The erroneous opinion prevails that black smoke contains a large amount of combustible matter and that it is a sign of greatly reduced economy. The most dense black smoke does not commonly contain more than ½ of 1 per cent of the combustible fired. The extreme fineness and the distribution of the carbon particles bestow upon them a high coloring power. The losses are negligible in comparison with those due to incomplete combustion or excessive air, which generally accompany combustion without visible smoke. The carbon particles producing visible smoke are not derived from a lifting of fixed or solid carbon from the grates, but they are formed from gases during the combustion process.—*Power*, September 18, 1917.

The War Convention of American Business, brought together at the call of the Chamber of Commerce of the United States, met at Atlantic City, September 17 to 21. The chief topic of discussion was the regulation and control of prices by the Government, the organization of war production, and the adjustment of business during and after the war. Suggestions were made that a war board should be created, similar to the Ministry of Munitions in England, which would control purchases for the Government, determine prices and control priority in distribution in order to do away with the competition between Government demands and those of private industry, which at present is working considerable hardship on business men over the country.

Among the educational institutions which have been patriotically devoting the summer recess to the intensive training of enlisted men should be mentioned Wentworth Institute. The institute has been giving such training to the men of the 101st Massachusetts Engineers, who have received quite a comprehensive outline of the essentials of machine-shop operations, steam engines, pumps, electrical construction and steam and electrical power-plant practice. An enormous amount of practical work has been accomplished and the thorough manner in which these young engineers have constructed a long series of trenches, bomb-proof shelters of reinforced concrete, dug-outs, etc., with all of the latest devices, emergency exits, drainage provisions, wire entanglements, suspension and pontoon bridges, electrical generating stations for use in the field to supply power, light and telephone and telegraph facilities for field operations, ensures their early participation in the actual operations in the field.

The present national crisis brings home to us the crying needs of the nation in availing itself of the knowledge and ability at its command. Fifty thousand specialists in applying scientific knowledge to practical problems as well as scores of research laboratories have offered their services to the nation. But problems requiring investigation are slow in being developed. Once they are formulated and given to the engineers of the country, few will remain unsolved very long.

It is for the engineer to apply the results of research to practical problems and to carry practical problems demanding general research back to the research laboratories. To the engineer, every special problem requires a special application of fundamental principles. Is it too much to hope that the day is rapidly approaching when all great problems, particularly those of our national and state governments, will be automatically placed in the hands of trained specialists? Not self-seeking politicians, nor yet men with mere theories, but engineers with a real command of fundamental principles, men with an unbroken record of big achievements and no failures, men ever ready to stake their all on their ability to handle problems in their specialty.—*Science*, September 14, 1917.

THE TRANSFER OF HEAT BETWEEN A FLOWING GAS AND A CONTAINING FLUE

By LAWFORD H. FRY, BURNHAM, PA.

Member of the Society

THE transfer of heat between a flowing gas and the wall of a metallic flue through which the gas flows is one of the most important processes in mechanical engineering, and as such has been the subject of much study by physicists and by engineers. All attempts, however, to bring the process under the yoke of a general formula have been very imperfectly successful.

The author now offers the formula described below, which within a wide range of conditions will represent with all the accuracy needed for practical work the processes of heat transfer between a gas and a metallic flue wall.

The formula applies equally well to the loss of heat by a hot gas in a cooler flue and to the gain of heat by a cool gas in a hotter flue, and although it has been established by purely empiric methods, yet the accuracy with which it conforms to the results obtained by various observers using widely differing experimental methods leads to the belief that it represents closely the fundamental law by which heat is transferred under the conditions under consideration.

The wide range of the experimental data on which the formula is based is shown in Table 1 and may be summarized briefly as follows:

Gases. The gases experimented with were products of combustion, lighting gas, CO and air, all at atmospheric pressure; also air at pressures ranging from 0.15 to 140 lb. per sq. in. abs.

Rate of Flow of Gas. The rates of flow ranged from 0.5 to 650 lb. per hr.

Flues. Flues of annular and circular cross-section were used, with effective diameters ranging from 0.5 to 2.0 in., and of lengths from 0.64 to 20 ft.

Temperatures. The inlet gas temperatures ranged from 2340 deg. fahr. with the products of combustion being cooled, to 55 deg. fahr. with air being warmed.

In all of the experiments throughout this wide range of conditions the transfer of heat is satisfactorily represented by the general formula proposed below.

GENERAL FORMULA FOR HEAT TRANSFER

The type of formula used is adapted from that suggested by Fessenden and Hedrick.[1] No attempt is made to measure the rate of heat transfer per square foot of heating surface per degree of temperature difference, but an expression is given for the rise or fall in temperature of a gas in its passage along a flue the wall of which is at a higher or a lower temperature than the gas.

If a gas flows at the rate of W lb. per hour through a flue of which the hydraulic depth is $d/4$ in. (in a flue of circular section the diameter corresponding to this hydraulic depth is d in.), and if the temperature of the gas be T_1 deg. in any given section and T_2 deg. in a section x ft. distant in the direction of the flow, and if the mean flue temperature between these two sections be t deg., all temperatures being measured from the absolute zero in any scale; then, if the gas temperature be higher than the flue temperature,

$$\text{lolog } T_1/t - \text{lolog } T_2/t = Mx \quad \ldots\ldots [1]$$

and if the flue temperature be higher than the gas temperature,

$$\text{lolog } t/T_1 - \text{lolog } t/T_2 = Mx \quad \ldots\ldots [1a]$$

where M is a constant in any given case, being dependent only on W the rate of flow of the gas, and on $d/4$ the hydraulic depth of the flue. In the experiments under consideration there is a critical rate of flow at about 5 lb. of gas per hr. At all rates of flow above this the value of the coefficient M is accurately given by the equations

$$\text{Log } M = A - m \log W \quad \ldots\ldots [2]$$

where

$$A = 1.558 - 0.185d \quad \ldots\ldots [3]$$

and

$$m = 0.14 + 0.083d \quad \ldots\ldots [4]$$

The application of Equation [1] is illustrated by Figs. 1, 2 and 3, which are based on one of the Babcock and Wilcox experiments in which products of combustion at a high temperature were passed through a water-jacketed flue and the temperature determined at a number of points along the flue. The abscissæ in all three figures are distances in feet from the furnace end of the flue. In Fig. 1 the ordinates of the curve are the gas temperatures T in degrees fahrenheit above the absolute zero. A horizontal line is also drawn having as ordinates the mean flue-wall temperature t.

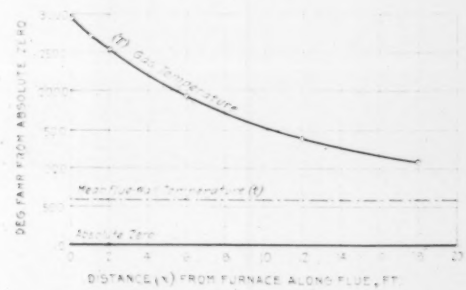

FIG. 1 MEAN GAS TEMPERATURES AND MEAN FLUE TEMPERATURE

(B. & W. Test 1, April 13.)

In Fig. 2 the ordinates are the logarithms of the ratio of gas temperature to mean flue temperature, log T/t, while in Fig. 3 the ordinates are the logarithms of the ordinates in Fig. 2, that is, they are the logarithms of the logarithms of the temperature ratios, [log (log T/t) or lolog T/t]. In Fig. 3 the points plotted fall on a straight line and it is obvious that if

[1] Trans. Am.Soc.M.E., vol. 38, p. 407.

[2] Chappell's very convenient logarithmic notation is used, by which "lolog N" denotes "the logarithm of the logarithm of the number N," all logarithms being to the base 10. (Five Figure Mathematical Tables, by E. Chappell.)

For presentation at the Annual Meeting, December 4 to 7, 1917, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Pamphlet copies of the paper may be obtained gratis upon application. All papers are subject to revision.

T_1 be the gas temperature at any point and T_2 the gas temperature at a point x ft. further along the flue the relation between the two temperatures is given by the equation

$$\text{lolog } T_1/t - \text{lolog } T_2/t = Mx \quad \ldots\ldots\ldots\ldots [1]$$

where M is the slope of the line.

The purpose of the present paper is (1) to show that this relation is a general one, and (2) to show how M, the coefficient measuring the slope of the lolog line, is affected by the rate of flow of the gas and by the flue diameter. It should be noted that the coefficient M is dependent not on the actual diameter of the flue but on the hydraulic depth, that is, on the quotient of the area divided by the perimeter. In the case of a flue of circular cross-section the hydraulic depth is one-quarter the diameter, and it is immaterial whether diameter or hydraulic depth be taken as argument in establishing the relationship with the coefficient M. As most of the present work concerns circular flues, it is convenient to use the "effective diameter" d in determining the relation between flue section

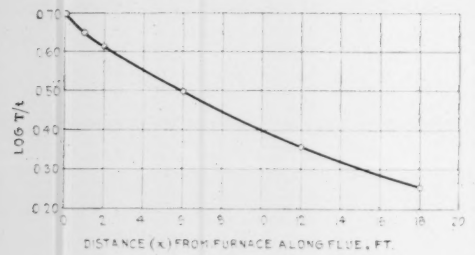

FIG. 2 LOGARITHM OF RATIO OF GAS TEMPERATURE TO FLUE TEMPERATURE

(B. & W. Test 1, April 13.)

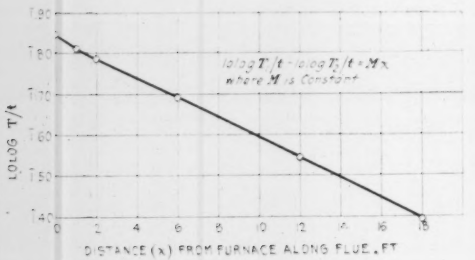

FIG. 3 LOGARITHM OF LOGARITHM OF TEMPERATURE RATIO

(B. & W. Test 1, April 13.)

and the coefficient M. This "effective diameter," being defined as four times the hydraulic depth, is the same as the actual diameter in a flue of circular cross-section. Examination of the experimental data has led to the conclusion that the relation between the coefficient M, the rate of flow of gas W, and the effective flue diameter d, is that shown above in Equations [2], [3] and [4].

EXPERIMENTAL DATA

The data on which the conclusions stated above are based have been derived from a total of 205 experiments, the range of conditions covered by them being shown in Table 1. These experiments fall into six groups, each of which is due to a different experimenter. The Jordan[3] experiments are among the most accurate, and as they cover a wide range of flue diameters, have played a considerable part in establishing the formulæ. They comprise five series, each with a flue of a different section. Two of the flues were annular and three circular in section, the effective diameter ranging from 0.506 to 1.968 in. The gas used was air, the rate of flow ranging from 30 to 620 lb. per hr. and the inlet temperature from 238 to 750 deg. fahr. The air was passed through a vertical flue 3.28 ft. long, surrounded by cooling water flowing in the opposite direction to the air. Inlet and outlet temperatures of the air were measured.

The Nusselt[4] experiments were made with air at a pressure of 140 lb. per sq. in., and with air, CO_2 and lighting gas at atmospheric pressure. These gases at atmospheric temperatures were passed through a horizontal flue 0.868 in. in diameter surrounded by steam at atmospheric pressure, and the rise in temperature measured. The length of flue in which the temperature rise took place varied from 0.64 to 1.96 ft. The rate of flow of gas varied from 1 to 400 lb. per hr. These experiments were carried out with great care and are valuable on account of the wide range of rate of gas flow, and because gases of various compositions were used. The Josse[5] experiments, like those of Nusselt, were made with a horizontal steam-jacketed flue, through which air at atmospheric temperature was passed and the rise in temperature measured. Pressures of 1.5, 7.5 and 15 lb. per sq. in. were used, the rate of flow ranging from 0.5 to 71 lb. per hr. The flue was 0.905 in. in diameter and 4.34 ft. long. The Babcock and Wilcox[6] experiments considered here are seven in number, taken at random from an elaborate series in which the products of combustion from a gas furnace were passed through a water-jacketed flue 2 in. in diameter and 20 ft. long. The gas inlet temperatures ranged from 1750 to 2350 deg. fahr., and as the water jacket was divided into twenty compartments each one foot long, the drop in temperature of the gas along the flue could be determined by measuring the amount of heat absorbed in each compartment of the jacket. The mean water temperature was approximately 160 deg. fahr. The Fessenden[7] experiments were very similar to the Babcock and Wilcox, but in one series a flue 1.816 in. in diameter and 10.95 ft. long, and in the other series a flue 0.816 in. in diameter and 10.44 ft. long, was used. In both series the jacket was divided into ten compartments in which water was allowed to boil at atmospheric pressure. Inlet and outlet temperatures were measured, and the drop of temperature along the flue could be found by measuring the amount of heat given up to each compartment of the jacket. The Pennsylvania Railroad[8] experiments are taken from tests of locomotives on the Altoona locomotive testing plant. One boiler had flues 2 in. in diameter and 18.75 ft. long, the other had flues 1.75 in. in diameter and 15 ft. long. The firebox and smokebox temperatures were measured in each experiment and the weight of the products of combustion determined from the flue-gas analysis.

DERIVATION OF FORMULÆ FROM EXPERIMENTAL DATA

The process of studying the validity of Equation [1] and of arriving at the law expressed by Equations [2], [3] and [4] is illustrated by Figs. 4 to 7.

The first step was to calculate from the figures obtained experimentally the value of the coefficient M in Equation [1]. This having been done and the results tabulated, it became evi-

[3] Proc. Inst. M. E., 1909, p. 1817.

[4] Mitteilungen über Forschungsarbeiten, vol. 89 (1910).

[5] Zeitschrift des Vereines deutscher Ingenieure, 1909, p. 322.

[6] Experiments on the Rate of Heat Transfer from a Hot Gas to a Cooler Metallic Surface. The Babcock & Wilcox Co., 1916.

[7] University of Missouri Bulletin, vol. 17, no. 26 (October 1916).

[8] Locomotive Tests and Exhibits; The Pennsylvania R. R. System, 1905. Tests of an E2A Locomotive; Locomotive Testing Plant Bulletin No. 5; Pennsylvania R. R. Co., 1910.

dent that in each series of experiments made with the same diameter flue the values of M decreased regularly as the rate of gas flow increased. In the search for the law governing this change the values of log M were plotted as ordinates over the values of log W as abscissæ, (W = lb. of gas per hr.). Fig. 5 showing the results obtained from Nusselt's experiments is typical and is of interest as covering the widest range of gas-flow rates and as covering gases of three different compositions and of widely different pressures. From this plot it appears that there is a critical rate of flow at about 5 lb. of gas per hr., $W = 5$, log $W = 0.699$, and that for rates of flow greater than this the relation between log M and log W is a well-marked straight line of the form log $M = A - m$ log W (Eq. [2]).

Before examining the numerical values of the coefficients in this equation, attention will be directed to the meaning of the two formulæ which have been set up. In Fig. 6, which is Fig. 5 redrawn in diagram form, AB represents the lolog of the temperature ratio at a given cross-section of the flue and CD the lolog of the temperature ratio at a section x ft. further along the flue. Then the slope of the line AC is determined by the value of the coefficient M. If the coefficient has a larger value, say M', the line will have a sharper slope and the value of lolog t/T_2 will be $C'D$, which is less than before. This means that the temperature T_2 will be greater than before. An increase in the value of the coefficient M corresponds to a more rapid interchange of heat between flue wall and gas, and consequently in the case under consideration, to a greater increase in the temperature of the gas.

The influence of the rate of gas flow on the coefficient M in any given flue is well illustrated by Fig. 5. As the rate of flow is increased the value of the coefficient M decreases, that is to say, the amount of change in the temperature of the gas between any two points decreases. For example, in Fig. 5 the line drawn through the plotted points of the Nusselt experiments shows the following values for log W and log M:

log W =	1.0	1.505	2.00	2.70
log M =	1.123	1.017	2.905	2.755

From which the following values are found for W and M:

W =	10	32	100	500
M =	0.1328	0.1040	0.08036	0.05689

If an initial gas temperature of 70 deg. fahr. be assumed, the temperature of the gas after passing 1 ft. along the flue which is maintained at 212 deg. fahr. will vary as follows:

Rate of flow, lb. per hr., W =	10	32	100	500
Temperature, deg. fahr, T_2 =	105.5	98.5	92.5	86.0
Rise in temperature, $T_2 - T_1$ =	35.5	28.5	22.5	16.0

The rise in temperature becomes less and less as the rate of flow is increased. If the amount of heat transferred to the gas is calculated from the foregoing, assuming a specific heat of 0.238, the following figures are obtained:

Rate of flow, lb. per hr. ..... W =	10	32	100	500
Heat transfer, B.t.u. per hr., 0.238 $W(T_2 - T_1)$ =	84.6	217	536	1910

From this it will be seen that when flowing at the rate of 10 lb. per hr. the temperature of the gas is raised 35.5 deg. out of a possible 42 deg., the transfer of heat being at the rate of 84.6 B.t.u. per hr., while if the rate of flow is increased to 500 lb. per hr. the temperature rise is only 16 deg., but the heat is transferred at the rate of 1910 B.t.u. per hr.

NUMERICAL VALUES FOR COEFFICIENTS

Returning to Equations [1] and [2] in order to evaluate the coefficients, Figs. 4 to 8 come under observation. The process adopted in deciding on the values given in Equations [3] and [4] was to plot on a fairly large scale values of log M as ordinates against values of log W as abscissæ. This having been done for the five Jordan series, for the Nusselt and for the Babcock and Wilcox groups of experiments, all of which can lay claim to a high degree of accuracy, it was evident that Equation [2], or log $M = A - m$log$W$, was universally applicable if the coefficients A and m were properly chosen to suit each flue. This is made clear by Fig. 4, in which all of the seven series just referred to are brought together in one plot. It is evident from this that the coefficients A and m which determine the position of the lines in this plot depend on the ef-

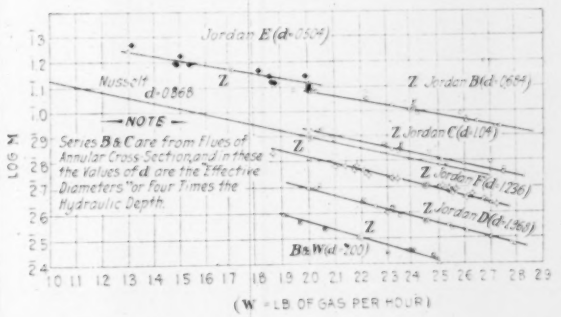
Jordan E (d=.0504)
Nusselt d=.0868
Z
Z Jordan B (d=.0654)
NOTE
Series B & C are from Flues of Annular Cross Section and in these the Values of d are the "Effective Diameters" or Four Times the Hydraulic Depth
Z Jordan C (d=.104)
Z Jordan F (d=.1236)
Z Jordan D (d=.1569)
B & W (d=.2001)
LOG M
(W = LB OF GAS PER HOUR)

FIG. 4 RELATION BETWEEN COEFFICIENT M AND RATE OF FLOW OF GAS FOR VARIOUS FLUE DIAMETERS

All lines are represented by the equation

$$\log M = \bar{1}.87 - (2.23 + \log W) m,$$

which may be written log $M = A - m$ log W, where $A = \bar{1}.87 - 2.23\ m$. This indicates that all of the lines if extended will pass through the point at which log $M = \bar{1}.87$ and log $W = -2.23 = \bar{3}.77$.

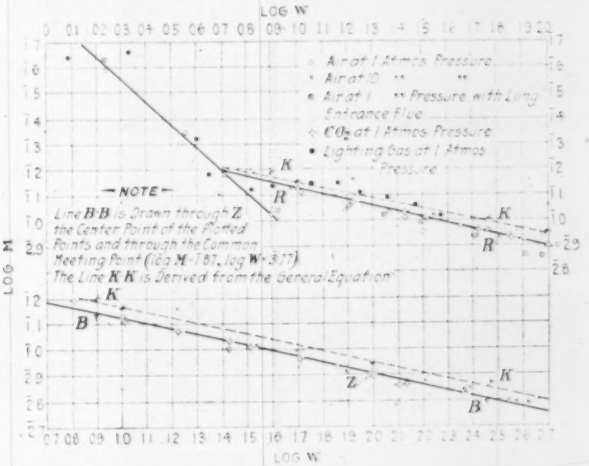
LOG W
Air at 1 Atmos. Pressure
Air at 10 " "
Air at 1 " Pressure with Long Entrance Flue
CO2 at 1 Atmos. Pressure
Lighting Gas at 1 Atmos. Pressure
NOTE
Line B-B is Drawn through Z the Center Point of the Plotted Points and through the Common Meeting Point (log M = 1.87, log W = 3.77)
The Line K K is Derived from the General Equation
LOG M
LOG W

FIG. 5 RELATION BETWEEN COEFFICIENT M AND RATE OF GAS FLOW FROM NUSSELT'S EXPERIMENTS WITH VARIOUS GASES

fective diameter of the flue. The problem is then narrowed down to the selection of values for these coefficients which shall be in some regular relation to the effective flue diameter, and which shall at the same time harmonize with the individual points derived from the experiments.

In studying this problem it was found that in each series of experiments the points plotted in Fig. 4 could be closely represented by a group of straight lines and all the lines thus obtained passed through point (log $M = \bar{1}.87$, log $W = \bar{3}.87$). In other words, the points representing the relation between log M and log W for all the experiments in the seven series now under consideration lie on a series of straight lines radiating

from the common point ($\log M = \overline{1}.87, \log W = \overline{3}.77$). Having discovered this property, the positions of the lines shown in Fig. 4 were established by choosing for each series of experiments a center point (these are the points marked Z in Fig. 4) and drawing lines through the common meeting point and through these center points.

Table 2 shows in columns 3 and 4 the coördinates of the center points selected for each series, and in columns 5 and 6 the values of the coefficients A and m for each of the lines passing through these center points and through the common meeting point. To connect these coefficients with the effective flue diameter they are plotted as ordinates in Fig. 7 over the flue

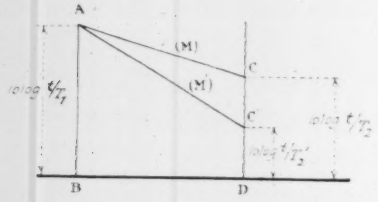

FIG. 6 DIAGRAM SHOWING EFFECT OF A CHANGE IN THE VALUE OF THE COEFFICIENT M

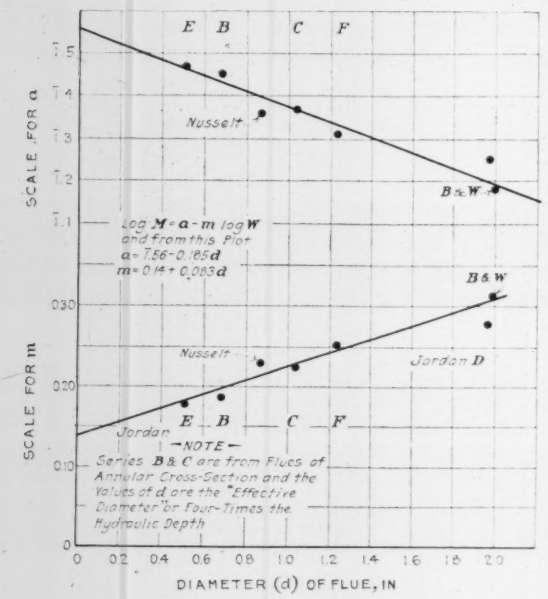
E B C F
Nusselt
B & W
Log M = a - m log W
and from this Plot
a = 1.56 - 0.185d
m = 0.14 + 0.083d
B & W
Nusselt
Jordan D
Jordan
E B C F
-NOTE-
Series B & C are from Flues of Annular Cross-Section and the Values of d are the "Effective Diameter" or Four-Times the Hydraulic Depth
SCALE FOR a
SCALE FOR m
DIAMETER (d) OF FLUE, IN

FIG. 7 RELATION BETWEEN FLUE DIAMETER AND COEFFICIENTS m AND A IN THE EQUATION LOG $M = A - m$ LOG W

The value of m being determined by the line drawn through the plotted values of m, the value of A follows from the equation $A = 1.87 - 2.23\ m$.

diameters d as abscissæ. All of the points lie fairly close to a straight line, and for the coefficient m a line with the equation $m = 0.14 + 0.083d$, or Eq. [4], was chosen as representing most satisfactorily the relation between m and d. Now since all of the lines in Fig. 5 are drawn to pass through the point ($\log M = \overline{1}.87, \log W = \overline{3}.77$), they can all be represented by the equation

$$\log M = \overline{1}.87 - (\log W - \overline{3}.77)\ m \quad \ldots\ldots\ldots\ldots\ldots\ldots [5]$$

which can be written

$$\log M = \overline{1}.87 - (2.23 + \log W)\ m \quad \ldots\ldots\ldots\ldots\ldots\ldots [5a]$$

since $\overline{3}.77 = -2.23$, or by regrouping,

$$\log M = (\overline{1}.87 - 2.23\ m) - m \log W \quad \ldots\ldots\ldots\ldots\ldots\ldots [5b]$$

Combining this with Equation [2], it follows that

$$A = 1.87 - 2.23\ m \quad \ldots\ldots\ldots\ldots\ldots\ldots [6]$$

and giving m the value found above in Equation [4], Equation [6] becomes

$$A = \overline{1}.56 - 0.185\ d \quad \ldots\ldots\ldots\ldots\ldots\ldots [3]$$

This completes the account of the development of the formulæ proposed. It now remains to consider their application to other independent experiments and to consider critically some portion of the work described above.

APPLICATION OF THE FORMULÆ TO OTHER EXPERIMENTS

In addition to those from the seven series of experiments considered above, experimental data from five other series are available for comparison. These are the two series by Fessenden, one by Josse, and two series of the Pennsylvania Railroad locomotive tests. For these experiments values of M were calculated as before and the values of $\log M$ plotted against $\log W$ in Figs. 8 to 11. In these figures the points are rather more scattered than in those previously considered, and the straight-line relation between $\log M$ and $\log W$ is not so clearly marked. This is probably due to a somewhat lower degree of accuracy in the experiments, and it was for this reason that these series were used for checking rather than for establishing the formulæ. The value of the coefficients A and m as determined by Equations [3] and [4] for the respective flue diameters are given for all twelve series of experiments in columns 7 and 8 of Table 2. The lines corresponding to these coefficients are drawn in in the various figures and marked K-K. In the Josse experiments, Fig. 8, the values of M given by the line K-K derived from Equations [2], [3] and [4] are slightly higher than those calculated from the experiments. The deviation of the line from the points is hardly greater than the discrepancies between the individual points. In view of the fact that no very elaborate precautions were taken to prevent errors in these experiments, it is quite probable that the formula represents the actual conditions at least as closely as do the figures derived from the experimental data. This series is also interesting, as it confirms the indication given by the Nusselt experiments of a critical gas speed at about 5 lb. per hr., $\log W = 0.699$. In the Fessenden experiments the points in Series I, Fig. 9, are very smoothly grouped and could hardly be better represented than they are by the line K-K given by the formulæ. In Series II, Fig. 10, the agreement between the calculated line K-K and the experimentally derived points is apparently not so close, but in this case the experimental conditions were such as to give a comparatively large variation in the coefficient M for a small variation in the heat absorption. In Fig. 10, for a rate of gas flow of 19.7 lb. of gas per hr., that is, $\log W = 1.295$, the value of $\log M$ from the formulæ as shown by the line K-K is $\overline{1}.15$, while the experimental points show $\log M = 1.05$. The experimental conditions corresponding to this rate of flow of gas show a temperature drop from 2003 deg. fahr. to 281 deg. fahr. in a flue 10.44 ft. long. The use of the calculated value of the coefficient M would change the outlet temperature from 281 to 238 deg. fahr., making the temperature drop 1765 instead of 1722 deg. This only means a difference of 2.5 per cent in the amount of heat absorbed from the gas, which is within the range of errors of observation in these experiments. There is therefore no real conflict between the experimental data and the formulæ proposed. The Pennsylvania Railroad locomotive tests, Fig. 11, show remarkably close agreement between the points derived from the experiments and the lines K-K given by the formulæ. A noticeable feature in this figure is the difference shown by the experiments in the value of the coefficient M in the two series of

TABLE 1 RANGE OF CONDITIONS COVERED BY EXPERIMENTAL DATA

Experimenter and Gas Used	Number of Experiments	Gas: Range of Temperatures, Deg. Fahr. Inlet Min.	Inlet Max.	Outlet Min.	Outlet Max.	Gas: Rate of Flow, Lb. per Hour Min.	Rate of Flow, Lb. per Hour Max.	Flue: Shape of Section	Effective Inside Diam., Inches	Length Used in Experiments, Feet Min.	Length Used in Experiments, Feet Max.	Range of Mean Wall Temperatures, Deg. Fahr. Min.	Range of Mean Wall Temperatures, Deg. Fahr. Max.	Conditions Surrounding Flue
JORDAN														
Series B Air	15	258	545	147	235	108	550	Annular	(0.684)	3.28		68	106	Gas flue surrounded by annular water flue carrying cooling water flowing in direction opposite to that of air flow.
Series C Air	14	357	750	245	373	108	600	Annular	(1.04)	3.28		55	126	
Series D Air	14	319	604	250	443	108	620	Circular	1.968	3.28		55	86	
Series E Air	12	365	637	154	258	30	98	Circular	0.506	3.28		72	130	
Series F Air	17	381	736	260	468	72	520	Circular	1.236	3.28		67	102	
NUSSELT										Min.	Max.			
1. Air at 14 lb. sq. in. abs.	13	78	155	109	187	1.6	108	Circular	0.868	0.89	1.95	217		Gas flue surrounded by steam jacket maintained at atmospheric pressure.
2. Same as 1, with long entrance flue	10	55	115	124	176	1.7	100	Circular	0.868	0.96	3.70	217		
3. Air at 140 lb. sq. in. abs.	12	62	115	81	148	16.6	420	Circular	0.868	1.96	1.96	217		
4. CO_2 at 14 lb. sq. in. abs.	10	70	125	108	150	6.4	137	Circular	0.868	1.00	1.96	217		
5. Lighting Gas at 14 lb. sq. in. abs.	12	74	144	124	177	1.0	38	Circular	0.868	0.64	1.96	217		
BABCOCK & WILCOX CO. Products of Combustion	7	1735	2340	377	649	94	313	Circular	2.0	17		160	200	Gas flue surrounded by water jackets each one foot long, to which cooling water is applied.
FESSENDEN Products of Combustion														Gas flue in each series surrounded by ten jackets to which water is fed and boiled at atmospheric pressure.
Series I	19	1473	1971	414	563	40.0	117.0	Circular	1.816	10.95		212		
Series II	17	1492	2003	247	306	11.8	25.8	Circular	0.816	10.44		212		
JOSSE														Gas flue surrounded by steam jacket maintained at atmospheric pressure.
1. Air at 14.7 lb. sq. in. abs.	7	62	70	138	171	5.3	71	Circular	0.905	4.34		212		
2. Air at 7.2 lb. sq. in. abs.	5	67	68	150	186	4.8	34	Circular	0.905	4.34		212		
3. Air at 1.5 lb. sq. in. abs.	5	80	96	162	188	0.5	37	Circular	0.905	4.34		212		
PENNSYLVANIA R. R. Products of Combustion														Experiments with locomotive boilers.
Series 600	11	1476	2177	500	689	64	171	Circular	2.00	18.75		390		
Series 900	17	1774	2266	562	740	121	252	Circular	1.75	15.00		387		

TABLE 2 VALUES OF COEFFICIENTS A AND m USED IN DRAWING B-B AND K-K LINES IN FIGS 4 TO 11

1 Experiments	2 Flue Diameter, Inches	3 Coordinates of Point Chosen as Center of Plotted Points: Log M	4 Coordinates of Point Chosen as Center of Plotted Points: Log W	5 Value of Coefficients A and m found for Line Drawn through the Center Point and through the Common Meeting Point Having Coordinates Log $M = 1.87$, Log $W = 3.77$: A	6 Value of Coefficients A and m found for Line Drawn through the Center Point and through the Common Meeting Point Having Coordinates Log $M = 1.87$, Log $W = 3.77$: m	7 Values of Coefficients Corresponding to the Flue Diameter d, as Given by the Straight Lines in Fig. 7 $A = 1.56 - 0.185d$: A	8 Values of Coefficients Corresponding to the Flue Diameter d, as Given by the Straight Lines in Fig. 7 $m = 0.14 + 0.083d$: m
Babcock & Wilcox	2.00	$\bar{2}.500$	2.20	$\bar{1}.18$	0.310	$\bar{1}.19$	0.306
Jordan Series B	(0.684)[1]	$\bar{1}.010$	2.40	$\bar{1}.455$	0.186	$\bar{1}.43$	0.197
Jordan Series C	(1.04)[1]	2.850	2.35	$\bar{1}.37$	0.223	$\bar{1}.37$	0.226
Jordan Series D	1.968	2.570	2.45	$\bar{1}.25$	0.278	$\bar{1}.20$	0.303
Jordan Series E	0.506	$\bar{1}.170$	1.70	$\bar{1}.47$	1.178	$\bar{1}.47$	0.182
Jordan Series F	1.236	2.705	2.45	$\bar{1}.31$	0.250	$\bar{1}.34$	0.243
Nusselt	0.868	$\bar{2}.905$	2.00	$\bar{1}.36$	0.228	$\bar{1}.40$	0.212
Fessenden, Series I	1.816	.....	.....	.....	.....	$\bar{1}.23$	0.291
Fessenden, Series II	0.816	.....	.....	.....	.....	$\bar{1}.41$	0.208
Josse	0.905	.....	.....	.....	.....	$\bar{1}.39$	0.216
Penna. R. R., Series 600	2.00	.....	.....	.....	.....	$\bar{1}.19$	0.306
Penna. R. R., Series 900	1.75	.....	.....	.....	.....	$\bar{1}.25$	0.285

[1] The flues in the Jordan series B and C have annular cross-sections. The values given in column 2 as diameters are the "effective diameters," or four times the hydraulic depth.

tests. The boiler-flue diameter was 1¾ in. in Series 900 and 2 in. in Series 600, and the difference between the values found by experiment for M in the two series corresponds exactly to the difference as calculated from the formulæ for the two different flue diameters.

The formulæ derived from the seven series of Jordan, Nusselt, and Babcock and Wilcox experiments are closely con-

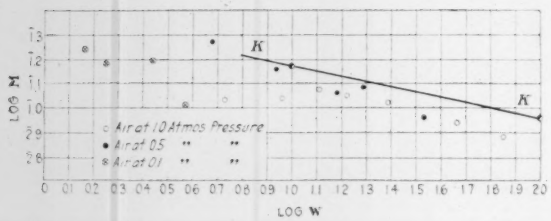

FIG. 8 RELATION BETWEEN COEFFICIENT M AND RATE OF GAS FLOW (W) FROM JOSSE'S EXPERIMENTS

(Line K-K derived from the general formula.)

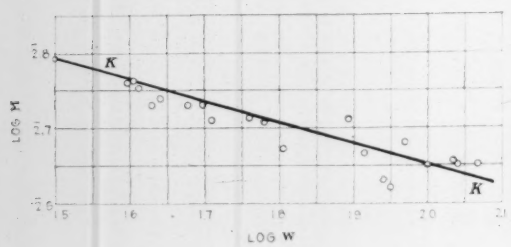

FIG. 9 RELATION BETWEEN COEFFICIENT M AND RATE OF GAS FLOW (W) FROM FESSENDEN'S EXPERIMENTS, SERIES I

(Line K-K derived from the general formula.)

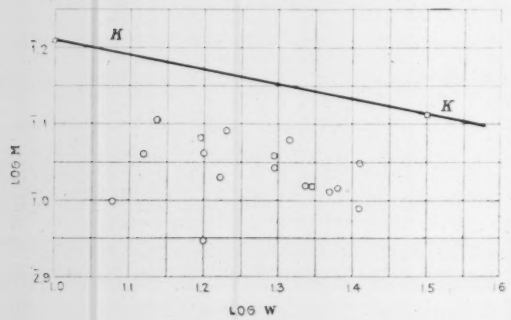

FIG. 10 RELATION BETWEEN COEFFICIENT M AND RATE OF GAS FLOW (W) FROM FESSENDEN'S EXPERIMENTS, SERIES II

(Line K-K derived from the general formula.)

CONCLUSIONS

firmed as to accuracy of results by the five series of Fessenden, Josse, and Pennsylvania Railroad experiments.

A DIAGRAMMATIC METHOD OF CONSIDERING THE PROCESS OF HEAT TRANSFER

Mechanism of Heat Transfer. In considering the problems connected with the transfer of heat between gas and flue wall, it is desirable to form some sort of mental picture of the physical processes which are in action. Fig. 12 is a diagram offered as a means to this end.

The gas is imagined to flow from left to right through the flue indicated in Fig. 12, while the dotted diagonal lines are intended to represent, in a very much simplified way, the path of individual particles of gas. Starting from a point in the center of the flue with a temperature of say T_{c_1}, a particle travels outwards and forwards until it impinges on the flue wall. For an instant the particle will flatten itself so to speak against the wall, and in this intimate contact will take on the temperature of the wall (T_w). It will then rebound at this temperature. During the rebound other particles approaching the flue wall will be encountered and there will be an interchange of heat and consequently of temperature, so that the temperature of the particles approaching the wall tends to approach the wall temperature before actual contact, while the particles leaving the wall tend to recover the center temperature T_{c_1}. As a consequence, when the particle first taken under consideration again reaches the center of the flue it will have a temperature T_{c_2}, which is higher or lower than T_{c_1} according as the wall temperature is higher or lower than the gas temperature. The process is repeated and on again

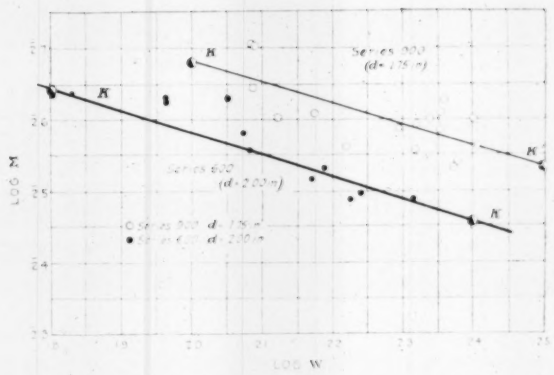

FIG. 11 RELATION BETWEEN COEFFICIENT M AND RATE OF GAS FLOW FROM PENNSYLVANIA RAILROAD LOCOMOTIVE TESTS

(Line K-K derived from the general formula.)

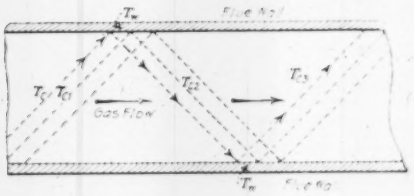

FIG. 12 DIAGRAM REPRESENTING PATH OF GAS PARTICLES AND TRANSFER OF HEAT

reaching the center the particle will have the temperature T_{c_3} and so on. This simplified way of looking at the heat-transfer process will give a correct understanding of the so-called film of dead gas supposed to adhere to the flue and to be scrubbed off to permit a more rapid rate of transfer when rate of flow of gas is increased. The particles, as has been said, are in contact with the flue wall for an instant and come away at the wall temperature, so that there is in effect a film of gas at the wall temperature close to the flue. This will to a certain extent protect the flue wall and cushion it against the particles coming from the center, but if the center particles do not strike the wall they impinge on the wall particles and effect an interchange of heat with these, some of which travel again to the wall, thus continuing exchange of heat between wall and gas.

If the amount of gas passing through the flue be increased heat is transferred between gas and flue at a faster rate, but this is not because the film of gas at wall temperature is swept off the flue wall, but because more particles are introduced to

bombard each unit of wall space. It must be remembered that while an increase in the rate of gas flow increases the rate of heat transmission, it at the same time reduces the efficiency of the process. This has already been dealt with, but in view of much that has been written on this subject, by Nicolson[9] among others, the point is worth emphasizing. Take the case of a boiler flue in which hot products of combustion are being cooled. A certain rate of flow gives a certain temperature drop and a certain amount of heat absorbed. If the rate of flow be doubled it will be found that the temperature drop is less than before; that is, the amount of heat absorbed from each pound of gas is less—the efficiency of the flue in absorbing heat has been reduced. Since, however, the weight of gas has been doubled while the amount of heat absorbed from each pound has not been halved, the total amount of heat absorbed is greater, that is, the effectiveness of the flue in absorbing heat has been increased. It would seem as though with the increase of gas flow there was an interference between the particles in their bombardment of the flue wall; although the number of hits is doubled the blows interfere with each other and are not so direct, with the result that though the amount of heat transferred is increased it is not doubled. In many cases advocates of high rates of gas flow fail to distinguish between effectiveness and efficiency.

The bombardment of the flue wall by the gas particles also serves to explain the effect of hydraulic depth on heat transmission. The hydraulic depth may be decreased either by reducing the diameter of the flue or by inserting a core so as to reduce the cross-sectional area while maintaining the perimeter (hydraulic depth = area/perimeter). With a reduced hydraulic depth the particles have a shorter distance to travel between center and wall, and consequently the same number of particles will make a greater number of hits in the same time and they will therefore effect the transfer of a larger amount of heat.

Gas Temperature. In setting out the various formulæ for change of temperature along the length of the flue, the temperature of the gas at various points along the flue has been spoken of. This was done with the understanding that the "temperature of the gas" in this sense is a term needing careful definition. In any section of the flue perpendicular to the longitudinal axis the temperature will vary from center to wall. The gas therefore has no definite temperature at that section, but the term "gas temperature" as used in the paper is to be understood as meaning the mean temperature of the gas crossing the section under consideration, that is, the temperature at which the gas if uniformly heated would carry past the section the same amount of heat as is actually carried. This temperature cannot be measured directly by a mercury thermometer or by a thermocouple. Nusselt measured the mean temperature, apparently with a fair degree of success, by means of a resistance thermometer formed of a spiral of wire wound on a mica cross in such a way as to traverse practically the whole sectional area of the flue. In this connection he points out that with pyrometers or bulb thermometers the radiation effect between instrument and flue wall will prevent accuracy of measurement.

Heat Transfer and Loss of Head. On considering the action of heat transfer as outlined above it will be apparent that there must be an intimate relation between the rate of heat transfer and the loss of head by the gas. As each particle impinges on the flue wall it loses (or gains) a certain proportion of its heat, and at the same time must, unless the flue wall be perfectly smooth—which is of course physically impossible, lose some of its velocity in the direction of the longitudinal axis of the flue.

Nusselt pointed out that Osborne and Stanton have dealt with this phase of the question mathematically, and Stuart[10] in discussing the performance of coolers for lubricating oil says that in the case of the oil and of the water flowing through the coolers the relative friction drops are of the same order as the relative heat-transfer factors.

The laws governing the loss of head by a fluid passing through a flue are still but imperfectly established, and it is suggested that a formula of the type given in the paper for heat transfer might be worked out to serve as a general formula for loss of head.

Such a general formula would be valuable, as loss of heat represents the price that must be paid for heat transfer. In any attempt to increase the rate of heat transfer by increasing the rate of flow of the gas, the limit is set by the loss of head. Beyond a certain point the loss of head, or in other words the amount of energy required to drive the gas through the flue, makes the gain in heat transfer unremunerative.

[9] Trans. Jun. Inst. Engrs., Jan., 1909.

[10] Journal Am. Soc. Naval Engineers, May 1917.

A STUDY OF SURFACE RESISTANCE WITH GLASS AS THE TRANSMISSION MEDIUM

By H. R. HAMMOND[1] AND C. W. HOLMBERG,[2] BROOKLYN, N. Y.

IN the study of heat transmission the determinations of the thermal resistances of material have been obtained in a more or less vague manner. At present the majority of coefficients used are combined coefficients; that is, no attempt is made at discriminating between the conduction of the material itself and the conductions of the two air spaces which exist adjacent to it. Consequently there are no standards by which surface resistance may be obtained. A method has been used by which the temperatures of the air, both outside and inside, were measured at a distance of 1 in. from the surface, but this has never been verified.

In an attempt to obtain some data on the subject of surface resistance with glass as the transmission medium, this paper will deal with the following points:

1 A study of the temperature gradients under various temperature differences between the inside and outside of the box
2 The relative values of conduction for the glass and for the air surfaces

[1] 256 Jefferson Ave.
[2] 354 Senator St.

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 4 to 7, 1917. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

3 The variation of the conduction values under the various temperature differences between the inside and the outside of the box.

THEORY

Heat may be transmitted from one side of a wall to the other in three ways: by radiation, by convection, and by conduction. In this paper, however, the radiation and convection factors will not be dealt with, and the formulæ which follow have to do only with conduction.

For total heat transmitted, we may write:

$$Q = k\ A\ (\triangle T) \quad \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

where Q = total B.t.u. transmitted per hour

k = transmission in B.t.u. per hour per sq. ft. per deg. difference in temperature

A = area of the surface in sq. ft.

$(\triangle T)$ = temperature difference, deg. fahr.

The value of k depends upon several factors: the surfaces, the thickness and kind of material, air spaces, absolute temperature, temperature difference, and condition of air at the surfaces. The combined transmission coefficient of a compound wall is determined from the sums of the reciprocals of the various conduction coefficients, as follows:

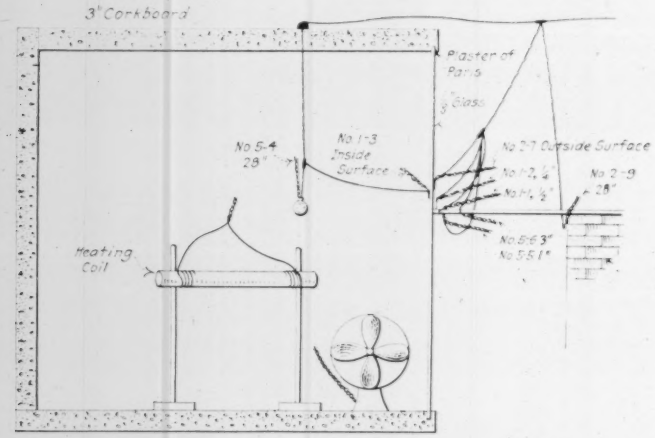

FIG. 1 APPARATUS FOR DETERMINING TEMPERATURE GRADIENT

$$k = \frac{1}{C_1} + \frac{x_2}{C_2} + \frac{x_3}{C_3} \cdots\cdots \frac{x_n}{C_n} + \frac{1}{C_{n_1}} \quad \ldots\ldots\ldots [2]$$

where C_1 = conduction of inside air surface in B.t.u. per hr. per sq. ft. per deg. difference in temperature

$C_2, C_3, \ldots C_n$ = conduction of material per hr. per unit thickness per sq. ft. per deg. difference in temperature

C_{n_1} = conduction of outside air surface in B.t.u. per hr. per sq. ft. per deg. difference in temperature

$x_2, x_3, \ldots x_n$ = thickness of material in inches.

PROCEDURE

The experiments were carried on in the thermal testing plant of the Pennsylvania State College, which consists of a room 17 x 17 x 10 ft., well insulated with corkboard and kept at a constant temperature by means of brine coils placed around the wall. Bulletin No. 9, Vol. 1, published by the Pennsylvania State College Experiment Station, contains illustrations and a complete description of this plant.

The experiments were made with a corkboard box (Fig. 1) 5 ft. by 5 ft. by 5 ft. 1 in. in outside dimensions and having a mean surface area of 141 sq. ft. The temperatures were recorded by platinum-resistance thermometers made by the Leeds & Northrup Co. and specially designed for this plant. Carefully calibrated voltmeters and ammeters were used to measure the heat input to the box.

Before proceeding with the tests the resistance thermometers and the box were carefully calibrated. The thermometers were calibrated by comparison with a standard mercury thermometer reading to 0.2 deg. and estimated to 0.01 deg. The thermometers were placed in a small box to protect them from any air currents that might affect the readings. The readings on the mercury thermometer were taken through a telescope in order that they might be estimated more accurately and not be affected by heat radiation from the person taking them. The resistance-thermometer readings were indicated by the usual Wheatstone bridge as supplied by Leeds & Northrup Co. Readings were taken of the various thermometers every ten minutes, and after a series of tests under different temperatures, the calibration curves were plotted.

In calibrating the corkboard box for different ranges of temperatures from inside to outside, a thermometer was suspended midway between the top and bottom and 10 in. from the inside surface, and another placed outside in the room. The room was kept at a constant temperature by means of brine circulating through coils around the room. Inside the box was placed a fan for the purpose of circulating the air and thus keeping the box at a uniform temperature throughout. The desired temperature was obtained by means of an electric heating coil placed in the center of the box. During the tests, readings were taken every ten minutes of the temperature inside and outside the box and of the voltage and amperage input. When the readings became constant they were considered acceptable and the rate of transmission in B.t.u. per hour per square foot was calculated from the formula

$$k = \frac{3.412 \times A \times V}{\text{mean area of box surface} \times \Delta T} \quad \ldots\ldots\ldots [3]$$

where A = ammeter reading in amperes.

V = voltmeter reading in volts

3.412 = heat equivalent of watts per hour

ΔT = temperature difference.

The calibration curve for the various temperature differences is plotted in Fig. 2.

After calibration the removable corkboard side was taken off and replaced by a glass plate ⅛ in. thick. Thermometers were placed at distances of ¼ in., ½ in., 1 in., 3 in., and 28 in. from the inside surface, also on the inside and outside surfaces and 28 in. from the outside surface. Tests were made in the same manner as when the box was calibrated.

All tests were run until the respective thermometers had maintained constant readings for some time. The arrangement of thermometers afforded ample opportunity to determine the temperature gradients.

Owing to the few available thermometers, it was not possible to run tests for inside and outside gradients simultaneously. Consequently the thermometers were rearranged as follows for the outside gradient tests: 28 in. inside, inside surface, outside surface, and ¼ in., ½ in., 1 in., 3 in., and 28 in. outside. All tests so far had been run with circulating air inside and still air outside. During this set-up, however, air currents were induced by a motor-driven fan which forced

air through a narrow slit-like aperture 1 in. wide and discharged across the surface of the glass with mean velocities at the thermometers of 800 and 1100 ft. per min. for two tests, respectively. Results of the outside gradient tests are plotted in Fig. 3, herewith shown. Two curves obtained under conditions of temperature and temperature range similar to those of the inside gradient tests were plotted in Fig. 4, together with the inside gradients as though they were obtained simultaneously.

On account of breakage, the plain glass window was now replaced by a four-pane window sash. Thermometers were placed at 28 in. inside, the inside surface, the outside surface and 28 in. outside the window. Tests were now run in the same manner as the preceding ones, especial care being taken to keep constant voltage and amperage in the heating coil, since these tests were primarily transmission tests. The combined transmission coefficient (k_1) of the window glass was calculated from the following formula:

$$k_1 = \frac{3.412\ V \times A - k_2 S_2 (\Delta T) - 0.8 S_3 (\Delta T)}{S_1 \times (\Delta T)} \quad \ldots [4]$$

where V = volts in heating coil
A = amperes in heating coil
S_1 = mean area of surface of 5 sides of corkboard box, sq. ft.
S_2 = mean area of surface of window panes, sq. ft.
S_3 = mean area of surface of sash (wood), sq. ft.
(ΔT) = temperature difference (inside—outside), deg. fahr.
0.8 = coefficient of transmission of wood
k_2 = coefficient of transmission of corkboard

The coefficient k_2 was calculated for various temperature differences as shown above and the results plotted in Fig. 5.

The conductions of the two air surfaces and the glass were determined similarly to the combined transmission coefficient, save that the value of (ΔT) in the denominator varied as the temperature differences of the various layers of material concerned. These curves are likewise plotted in Fig. 5 for the purpose of comparison.

SAMPLE CALCULATIONS

When $(\Delta T) = 23.15$ deg. fahr.,

k_1 (combined transmission coefficient of glass) =

$$\frac{(3.412 \times 49.5 \times 4.51) - (0.8 \times 0.58 \times 23.15) - (117.3 \times 23.15)}{21.4 \times 23.15} =$$

$$\frac{770 - 10.75 - 277}{495} = \frac{482.25}{495} = 0.974$$

C_1 = conduction of glass $= \dfrac{482.25}{21.4 \times 1.26} = 17.88$

C_i = Conduction of inside air surface $= \dfrac{482.25}{21.4 \times 7.93} = 2.84$

C_o = conduction of outside air surface $=$

$$\frac{482.25}{21.4 \times 13.96} = 1.615$$

DISCUSSION OF RESULTS

When plotted, all of the temperature gradients from the surface proved to be smooth curves. This result amply justified the method of testing which was employed during the entire series of tests, both gradient and transmission. In this method of testing the authors continued the test until constant readings in the respective thermometers had been maintained for some time. The time elapsing before this condition was obtained varied between two and eight hours.

The inside gradients bent down sharply within the first quarter of an inch. Then the curves grew flatter, until at a distance of $\frac{1}{2}$ in. from the surface of the glass the curves became constant. The outside gradients were more gradual in character, the major part of the drop occurring in the first two inches from the glass for still-air conditions, while the gradients obtained under moving air were considerably flattened and reached a nearly constant value within the first inch.

These results would indicate that the circulating air inside

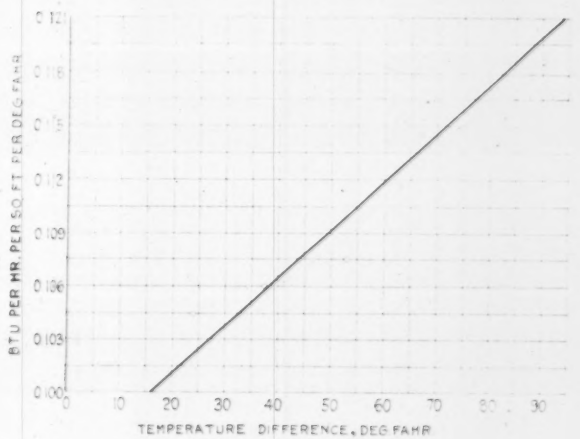

FIG. 2 TRANSMISSION OF CORKBOARD BOX

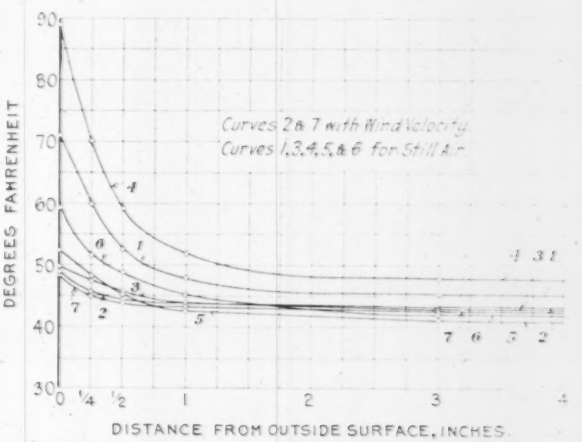

FIG. 3 OUTSIDE TEMPERATURE GRADIENTS

cut down the air resistance film at the surface of the glass and thus increased the conduction of the air layer.

Under still-air conditions the outside surface resistance was considerably greater than with moving air. This was undoubtedly due to the fact that much heat was carried away by convection.

These tests indicate that the resistance is greatest very close to the surface of the glass and that when performing experiments in heat transmission it is best to place the outside thermometer not less than 2 in. from the surface under still-air conditions; and not less than 1 in. under moving-air conditions when the air velocity is greater than 800 feet per minute.

The combined transmission coefficients and the conduction

values for the glass inside air surface and outside air surface were calculated by formula [4] and are as follows:

	Temperature Range, Deg. Fahr.			
	23.15	40.37	54.45	73.52
Combined transmission	0.974	1.079	1.159	1.165
Conduction of glass	17.880	18.050	19.800	19.890
Conduction of inside air surface	2.840	3.315	3.650	3.560
Conduction of outside air surface	1.615	1.750	1.850	1.900

The combined coefficient values check up fairly well with the values 0.96 (dry glass) and 1.1 (wet glass) for a single

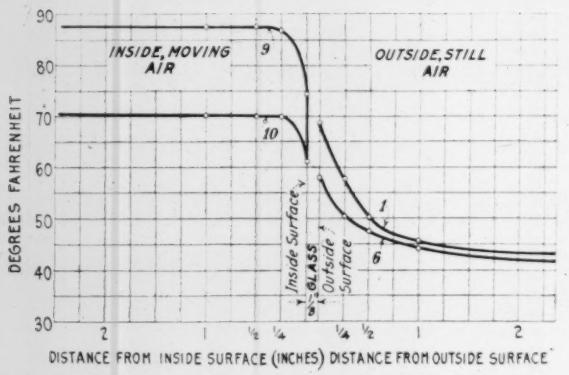

FIG. 4 COMBINED INSIDE AND OUTSIDE GRADIENT

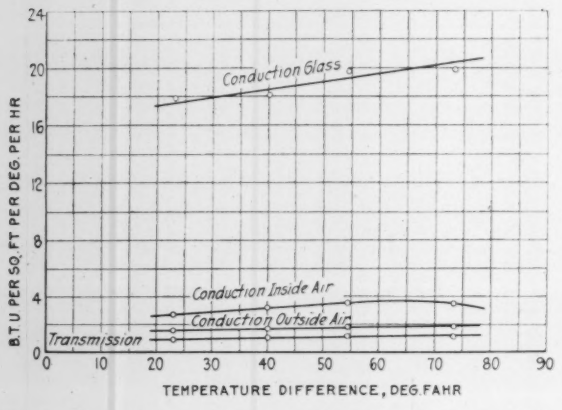

FIG. 5 CONDUCTIONS THROUGH AIR SURFACES AND GLASS

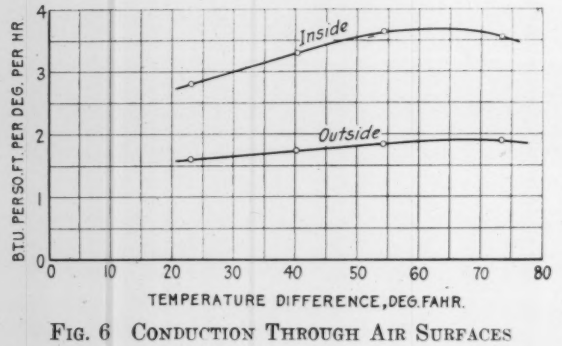

FIG. 6 CONDUCTION THROUGH AIR SURFACES

window ⅛ in. thick, given in Greene's Elements of Heating and Ventilation. Moreover, they show that the transmission varies linearly with the temperature differences, as the curve plotted in Fig. 5 will demonstrate.

The conduction values for the glass under the same temperature differences show that they also varied in the same way as the combined transmission values.

The conduction values for the air surfaces confirm the results of the gradients, in that the resistance of the outside air surface is shown to be considerably less than that of the inside air surface. Curves of the surface resistance plotted to an enlarged scale in Fig. 6 show that the conduction of the surfaces is greatest at points where the temperature ranges vary from 65 deg. to 75 deg. This seems to indicate that there is a saturation point at which the transmission through the air layer cannot be increased. The writers believe that it would be highly desirable that further investigations be undertaken in order to check up this point.

Fig. 5 shows the relationship between the conductions of the air surfaces and the glass. It can be seen that the resistance of the glass is very slight as compared with that of the air surfaces. This proves that in figuring transmission through glass the resistance of the air layers at the given conditions will be the primary factors, since from the figure it is shown that they form the bulk of the resistance which goes to make up the combined transmission factor. In connection with this point it is interesting to note the investigations carried on by Professor Moyer in the Pennsylvania State College Thermal Testing Plant, and described in the *A. S. R. E. Journal*, Vol. 2, No. 3. Professor Moyer's results indicated that the influence of air velocity on transmission through glass caused the transmission coefficient to vary from a value of 1.263 at zero velocity to 4.207 at a velocity of 1200 ft. per min. This illustration further proves the extreme importance of the air surface resistance on the combined transmission factor.

Consequently, the subject of air resistance seems worthy of careful investigation as to its behavior under varied conditions. The writers in suggesting further investigation along this line would say that they consider thermocouples preferable to resistance thermometers. Resistance thermometers, on account of their appreciable size and consequent susceptibility to radiation, make very accurate surface readings impossible, while the fine-point contact of the thermocouple makes it very desirable in this connection. Delay in obtaining thermocouples caused the writers to use resistance thermometers in these tests.

The writers are indebted to Prof. R. B. Fehr of the Pennsylvania State College Thermal Testing Plant for some of the data used.

CONCLUSIONS

A summary of the more important results obtained in the tests is as follows:

1 The gradient tests demonstrate that the greater part of the air-layer resistance occurs at the outside and within the first half inch of the surface.

2 Whenever glass or any other good conductor is used as the transmission medium, the resistances of the inside and outside air surfaces play the major part in determining the combined transmission coefficient.

3 The tests show that the transmission through glass and through corkboard with temperature differences ranging from 20 deg. to 80 deg. varies linearly with these temperature differences.

The writers wish to acknowledge much valuable assistance received from Prof. A. J. Wood and R. B. Fehr, and from the Penn State College.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Departments of The Journal by members of The American Society of Mechanical Engineers are solicited by the Publication Committee. Contributions particularly welcomed are suggestions on Society Affairs, discussions of papers published in The Journal, or brief articles of current interest to mechanical engineers.

Steam Locomotive Practice

TO THE EDITOR:

Among the papers constituting the Symposium on Steam Locomotives held by the Minnesota Section, I find a number of points of interest, which might be considered more extensively with profit. Prof. G. L. Hoyt calls attention to the fact that, in many cases, the use of special heat-treated steel has not been accompanied by a modification in design, so that the advantages of the higher-priced metal could be fully obtained. This is a point that is not readily understood, and is especially true in the case of springs, where the alloy steel costs double and should have double strength, but the manufacturers recommended the same load limits, viz., 70,000 to 80,000 lb. per sq. in., that had been used for years in plain carbon steels. It was explained that you had double the "factor of safety" that you obtained with carbon steel, but this never appealed to the writer as being a sound engineering argument. Factors of safety are too often "factors of ignorance," and as such are not desirable quantities to increase, especially at double the price.

These recommendations to use high-priced heat-treated alloy steels without realizing the benefits for which we pay by a reduction in the quantity of metal used, always convey the impression that the particular heat treatment used may *not* give us all that is claimed for it. Heat treatment is quite a difficult process to control properly in a large plant, where the conditions of operation are evidently very different from those that obtain in an experimental laboratory, where the whole treatment is under the eye of a specialist instead of depending upon ordinary labor. Pyrographic charts will tell what temperatures *have existed* at certain *points* in the *furnace*, but the temperature of the particular piece under treatment is quite another matter.

The writer does not wish to be considered skeptical of the value of alloy steels—far from it, but he has seen so many instances of things being "seldom what they seem" in the heat-treated line that he does not always have as much faith in the results of that process as he would like to have, and it seems possible that such fears may be the basis for maintaining old dimensions in the parts made of alloy steels.

Coming to Pulverized Fuel in Locomotives, the writer is in hearty accord with the efforts of Mr. Muhlfeld to obtain greater output from locomotives by this method of combustion. Many years before locomotive stokers achieved the success which they now enjoy, he (the writer) pointed out the necessity for increasing the steam output beyond the human muscular limits of the fireman, which were about 5000 to 6000 lb. of coal per hr., and favored the introduction of stokers on locomotives which should have the firebox especially designed for this purpose, instead of trying to crowd in the stoker apparatus and mechanism where the construction was not suitable for producing the best results. The same must be true of pulverized coal, and prejudice in adhering to conventional lines should not be allowed to interfere with the success of this method of firing locomotives. This has been the crucial point in many improvements, and fear to leave what our fathers have done has sounded the death knell of many valuable efforts for progress.

At the present time the success of feedwater heaters on locomotives seems to be more dependent upon the pump than any other feature of the device. Simple as this part of the problem seems to be, it is one very difficult of satisfactory solution. Reciprocating pumps jar themselves and their parts loose and go out of commission just when the engineer has neither time nor opportunity to "tinker" with them. Rotary pumps at high speed have difficulties of their own, due largely to the unsatisfactory foundations which must be furnished by the locomotive structure. Bent spindles and other troubles follow insufficient rigidity, and the small space available for this apparatus prevents securing the best results. The weakest link in a chain is often located where we least expect, and compromises the whole structure by its breakdown. So an unsatisfactory pump will put a "curse" upon a feedwater system that it cannot survive, no matter how efficient the heater.

GEO. R. HENDERSON.

Philadelphia, Pa.

TO THE EDITOR:

The symposium on steam locomotives, held by the Minnesota Section on March 10, was certainly most instructive, but I feel that one point in connection with the various appliances and devices described was not given sufficient importance. To one familiar with development of steam locomotives in the past few years, there is no question but that the superheater and brick arch have had a very intimate connection with the increase in size and power of our locomotives. The railways have been continually seeking for larger and larger units of power, with but slight changes in physical limitations under which this power must operate (weight per pair of wheels, height and width limits and amount of coal which can be fired per hour), and the increased capacity afforded by superheat and the brick arch has permitted an increase in the size of locomotives far beyond that which would have been possible without them.

In the papers which were read descriptive of various improvements, emphasis was laid upon the economies in operation which these improvements effected. It has been the history of railroading that advantage is at once taken of any device which makes for economy or efficiency in obtaining *additional capacity*.

How much has already been accomplished in this matter is evident from a comparison of the horsepower output of a typical first-class locomotive built about 1904-05 and that of one of recent design. An average fireman can handle about 5000 lb. of coal per hour. In 1904 we were obtaining from our best designs of simple locomotives without superheaters about 1100 to 1200 i.hp. per hour from 5000 lb. of coal. Today we are obtaining from the same amount of coal about 2000 to 2100 i.hp. per hour.

These latter figures were obtained from locomotives having superheaters and brick arches, together with other refinements of design introduced in the past few years. It is evident that the enormous strides in increased capacity and size could not have been made had it not been possible to obtain more work from a pound of coal by taking advantage of the increased efficiency due to these improvements.

Two of the latest developments which will make possible still further increases in capacity and power, and which were not included in the above comparison of locomotives in 1904 and 1905 and at the present time, are the feedwater heater and the use of pulverized fuel. Both of these developments are unquestionably capable of yielding material economies which will undoubtedly be utilized in still further increases in the capacity of locomotives.

In the past there have often been statements made that we had reached the limit of size and power of locomotives, but it is significant that of late there have been fewer of such statements. The improvements and developments which were described at the meeting of the Minnesota Section have removed many of the limitations which previously confronted locomotive designers, until at the present time men who are familiar with the latest developments in this field hesitate to make any predictions as to limits of capacity and size of future steam locomotives.

W. E. WOODARD.

Lima, Ohio.

Mobile Armament for Defense

TO THE EDITOR:

Replying to the comments of Mr. Arthur F. Cary on Mobile Armament for Defense, published in the September issue of THE JOURNAL, I beg to state:

1 The standardization of ammunition for various calibers of guns is a very interesting matter, but is foreign to the subject under discussion.

2 As to the practicability of the gun having a breech block sliding against a surface plate: There is no tendency to dent the surfaces, which are hardened and are of sufficient area to withstand the load imposed. This load is a static pressure and is not in the nature of a blow; means being provided to bring the surfaces in contact, although a working clearance is allowed when elevating the gun.

3 With reference to the methods of supporting railroad cars from which guns of moderate size are fired: The outriggers and jackscrews have been adopted for the reason that they admit of adjustment to almost all conditions of the roadbed. In order to secure mobility it is necessary to keep the supports as nearly as possible within the limits of the roadbed. Beyond the actual roadbed the ground may be unsuitable to support any load. The tripod arrangement suggested by Mr. Cary presents several difficulties. The struts would have to extend from a point only a little below the trunnions, otherwise they would be subjected to a bending movement and would have to be made heavy. It would be interesting to see this tripod arrangement worked out for firing a gun from a car on a banked track say eight feet above a New Jersey marsh.

4 The independent drive for railroad cars is in use to some extent on the Pacific Coast. This is one of the good things that come from the West and travel East. It may replace the horse cars in some parts of New York.

ANDREW M. COYLE.

New York, N. Y.

Strength of Boiler Furnaces

TO THE EDITOR:

Referring to Par. 6 of the letter from Mr. John Airey in the July number of THE JOURNAL, I will quote the part of the Board of Trade rules pertaining to pressure allowance on plain circular furnaces, as follows:

$$\text{Plain Furnaces}^1. \quad \text{W. P.} = \frac{C \times T^2}{D(L+1)}$$

TABLE OF VALUES FOR C

Longitudinal Seams of Furnace	Iron		Steel
	Drilled	Punched	Drilled
Single butt straps double-riveted, or double butt straps single-riveted	90,000	85,000	99,000
Single butt straps single-riveted, or lap-beveled and double-riveted	80,000	75,000	88,000
Lap not beveled, double-riveted	75,000	70,000	82,500
Lap beveled, single-riveted	70,000	65,000	77,000
Lap not beveled, single-riveted	65,000	60,000	71,500
Longitudinal seams welded	90,000		99,000

In no case should the working pressure exceed the values found by the following formulæ:

$$\text{W. P.} = \frac{9000\,T}{D} \text{ for iron}$$

$$\text{W. P.} = \frac{9900\,T}{D} \text{ for steel.}$$

From this it will be noted that for a plain circular furnace

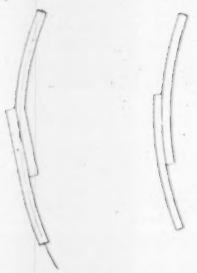

FIG. 1 FIG. 2

FIG. 1 BEVELED LAP SEAM
FIG. 2 ORDINARY LAP SEAM

with a single-riveted lap seam the formula is: $\frac{77{,}000\,T^2}{(L+1)D}$. This gives a pressure of 75 lb. on the furnace of the dimensions given by Mr. Airey, as stated in my communication in the February issue of THE JOURNAL. The constant 77,000 pertains to furnaces in which the single-riveted lap seam is properly formed or "beveled" so that the furnace cross-section is a true circle (Fig. 1).

When such a joint is made as shown in Fig. 2 the constant to be used is 71,500, which would give a pressure of 69 lb. without further deduction for the efficiency of the longitudinal joint.

Comparing the above constants and assuming 100 per cent for the collapsing strength of a flue with a welded seam or one with a double butt-strap joint, which are the easiest to make truly round, we get an efficiency of 71,500/99,000 = 72.2

[1] Copied from quotation of Board of Trade rules in Stromeyer's Marine Boiler Management and Construction.

per cent allowed by the Board of Trade rules for the kind of joint shown in Fig. 2.

While Mr. Airey's mathematical analysis of the efficiency of this joint in compression, which was published in the Journal of the American Society of Naval Engineers, appears a safe approximation, it would not seem that the theoretical result of 27.6 per cent (or about two-fifths of the Board of Trade allowance) he thus obtains need seriously be considered in view of the experience of several decades during which the Board of Trade constants have been operative unchanged in localities where boilers with (riveted) furnace flues always have been proportionally far more numerous than in the United States. It appears quite probable that the failure of the actual flue mentioned by Mr. Airey was due to general out-of-roundness in addition to the fact that the most unfavorable joint was used.

Upon the strength of Mr. Airey's analysis he is not justified in referring in a general way to "the weakness of a lap joint," since a lap joint that is properly formed as in Fig. 1 does not produce the unfavorable feature of making a cylinder out of round, and his analysis pertains only to Fig. 2.

One important point this discussion has brought out is that from the present wording the A.S.M.E. Boiler Code rules may be construed as permitting the use of longitudinal lap joints that are not properly formed for furnace flues, as all lap joints in compression should be, so that true circularity is obtained. It might be well to specifically prescribe this in the various paragraphs of the Code where longitudinal lap joints for flues are mentioned, just as the proper curvature for longitudinal joints of boiler shells now is prescribed.

H. J. VANDEREB.

Hartford, Conn.

WORK OF THE BOILER CODE COMMITTEE

Ten Years of Boiler Standardization

THE conception of a standard specification for steam boilers was first advocated, I believe, by Mr. Joseph H. McNeill, who for many years was the very able chief inspector of the State of Massachusetts Boiler Inspection Department, and through the very earnest endeavors of Mr. McNeill and the operating engineers of Massachusetts, most ably sponsored by the late Hon. Curtis Guild, Jr., Governor of Massachusetts and later Ambassador to Russia, the Massachusetts Board of Boiler Rules was created. The writer looks back with pleasure to being one of the members of the original Board, on which he represented boiler-using interests, and which included Joseph H. McNeill, Chairman; Frederic H. Keyes, representing boiler-manufacturing interests; Robert J. Dunkle, representing boiler-insurance interests, and William M. Beck, representing operating engineers.

Upon the retirement of Mr. Frederic H. Keyes, Mr. Bartholomew Scannell, of Lowell, Mass., one of the patriarchs of the boiler industry in this country, was appointed in his place. Upon Mr. Scannell's resignation, Mr. Henry H. Lynch was appointed.

The late Mr. Thomas R. Armstrong was also a member of the Massachusetts Board of Boiler Rules at one time.

The first meeting of the Board was held on July 5, 1907, in a very small and hot room on the fifth floor of the State House at Boston. At this meeting Mr. McNeill stated to the other members of the Board his ideas of a standard specification for all stationary boilers to be used within the Commonwealth of Massachusetts.

We forthwith set to work to formulate a standard which would be first of all safe, and second commercial. We held meetings weekly and oftener for practically the first three years of the service. Incidentally it might be mentioned that the correspondence was very prolific; it came from all known authorities whom we could interest enough to send us any good data they had on boilers which would make the steam boiler of the future reasonably safe, and almost without exception we had prompt and efficient replies from all those well qualified to give advice.

From time to time, as we were in a position to do so, we issued pamphlets of instructions to boiler manufacturers and inspectors, stating how the rules should be applied in the construction of boilers, until we published the Rules of August 5, 1909, which was the last and main issue made by the original members of the Massachusetts Board of Boiler Rules and embodied all that was necessary for the guidance of those manufacturing and inspecting stationary steam boilers for the Commonwealth of Massachusetts for that period.

While this work was going on, the forces in the Inspection Department were augmented, more rigid watch was kept of existing boilers, and more thought, patience and skill put into the manufacture of new boilers; in other words, the educational process was advanced and has advanced ever since Mr. McNeill started this system.

In the meantime, the writer made a trip to Europe and interviewed several of Europe's greatest boiler engineers with special reference to additions or deductions from our Rules, and we were very highly complimented in Europe on the rules formulated.

The present Massachusetts Board of Boiler Rules consists of

GEO. A. LUCK, Chairman.
FREDERICK A. WALLACE, Representing Boiler-using Interests.
HENRY H. LYNCH, Representing Boiler-manufacturing Interests.
ROBERT J. DUNKLE, Representing Boiler-insurance Interests (member of Board since its inception).
EDWARD D. MULLANE, Representing Operating Engineers.

In addition to its boiler-standardization work the Board has formulated very valuable air-tank regulations.

In 1911 the late Col. E. D. Meier, then president of The American Society of Mechanical Engineers, suggested in his wonderful foresight that The American Society of Mechanical Engineers undertake the work of standardization of steam boilers in a more complete manner than was possible with the State of Massachusetts, and the writer was appointed Chairman of the original committee of The American Society of Mechanical Engineers for the purpose of creating a standard for that Society. This committee was called The Committee to Formulate Standard Specifications for the Construction of Steam Boilers and Other Pressure Vessels and for their Care in Service, and originally consisted of

JOHN A. STEVENS, Chairman	CHAS. L. HUSTON
WM. H. BOEHM	EDWARD F. MILLER
ROLLA C. CARPENTER	H. C. MEINHOLTZ (Deceased)
RICHARD HAMMOND	E. D. MEIER (Deceased)

Upon the death of Mr. Meinholtz, Col. E. D. Meier was appointed in his place.

Colonel Meier took a most active part in the formation of the A.S.M.E. Boiler Code, and up to within a few days of his death had it constantly before him. It is one of the regrets of the members of the Boiler Code Committee that he could not have lived to have seen the fruition of the work he so wisely started.

The A.S.M.E. Committee proceeded on similar lines to those followed by the Massachusetts Board of Boiler Rules in counseling with all qualified authorities, manufacturers and large users of boilers, producing its preliminary report and thereafter issuing at different times other preliminary reports up to the issue given to the public in 1914.

At one stage in the work it was found advisable and necessary to amplify the original Committee by appointing an Advisory Committee composed of some of our most celebrated steam engineers, for it was believed that the great interests of our country should not have "taxation without representation," and it has always been admitted that boilers built to the standard of The American Society of Mechanical Engineers cost more money than boilers built otherwise, and are indeed worth more.

In appointing the Advisory Committee, men were chosen to represent all of the large interests affected, such as railroads, consulting engineers, large manufacturers of different types of boilers and engineering schools. Their keen interest was thus secured in the promulgation of standards among our engineering institutions, steam-heating boiler manufacturers, water-tube-boiler manufacturers, boiler-insurance companies, threshing interests and boiler users.

The members of this Advisory Committee consisted of the following:

F. H. CLARK, Railroads.
F. W. DEAN, Consulting engineers.
THOS. E. DURBAN, Boiler Manufacturers' Association, Uniform Specifications Committee, for all types of boilers.
CARL FERRARI, National Tubular Boiler Manufacturers' Association.
ELBERT C. FISHER, Scotch marine and other types of boilers.
ARTHUR M. GREENE, JR., Engineering education.
CHAS. E. GORTON, Steel heating boilers.
A. L. HUMPHREY, Railroads.
D. S. JACOBUS, Water-tube boilers.
S. F. JETER, Boiler insurance.
WM. F. KIESEL, JR., Railroads.
W. F. MCGREGOR, National Association of Thresher Manufacturers.
M. F. MOORE, Steel heating boilers.
I. E. MOULTROP, Boiler users.
RICHARD D. REED, National Boiler & Radiator Manufacturers' Association.
H. G. STOTT,[1] Boiler users.
H. H. VAUGHAN, Railroads.
C. W. OBERT, Secretary to Committee.

In the appointment of the Advisory Committee, we were most fortunate in selecting men who proved to be real workers, and who moreover were naturally possessed of analytical minds, men not afraid to admit when they were wrong and not afraid to be insistent when they were right.

The writer wishes to mention especially the great assistance given the Committee throughout the early stages of the formulation of the A.S.M.E. Boiler Code by Mr. Henry Hess, Vice-President of the Society, who counseled with and guided us with special reference to our conferring with other large societies interested in standardization work, notably the American Society for Testing Materials, and also other societies which were more or less interested in a boiler standard. He also very wisely advised us not to have anything to do with legislation or politics; had we not heeded this advice we would probably have caused the downfall of the Code early in its life.

Space prevents mentioning the great assistance accorded the Committee by manufacturers of boiler material, irrespective of their own desire to manufacture only one standard material for boilers, also the great help given by the boiler-insuring interests, and that offered by the railroad interests of America, and by the large boiler users.

Throughout the entire formulating period of this work the writer was most ably assisted by his associate-engineer, Mr. Walter Slader, and he wishes here to give this gentleman credit for the very valuable work he did throughout this long and arduous task. In passing, he wishes also to give all due credit to *Power*, *The Boiler Maker*, and several other engineering periodicals which have from time to time issued articles in sympathy with the movement.

The work of the Boiler Code Committee of The American Society of Mechanical Engineers was founded on the standards originated by the Massachusetts Board of Boiler Rules, but it should be noted that the work is a great deal more complete and far-reaching than the Massachusetts Standard. In the first place, the A.S.M.E. Code specifies in detail the chemical and physical properties of all material entering into the construction of boilers, and gives rules, formulæ and tables which have been checked and rechecked by men of national reputation and in many cases verified by testing laboratories; that is to say, in many cases, rules or formulæ were withheld until actual tests in laboratories had been made in order to prove the mathematics.

Therefore, it is with pleasure that we note that the Code has been adopted, or is in the process of adoption, in great states such as New York, New Jersey, Pennsylvania, Ohio, Indiana, Michigan, Wisconsin, Minnesota and California, and such cities as Kansas City, Scranton, Pa., and St. Louis, Mo., and even in the Argentine Republic and the Republic of Paraguay, South America.

This would indicate that the Code has been through a very severe process of trial and has been found to be, as stated, the best in existence for governing the construction and inspection of stationary boilers.

It is also gratifying to the writer to note that, according to Specification No. 2362 for power-plant equipment at the Naval Training Station, Newport, R. I., boilers and accessories used by this department are to be in accordance with the A.S.M.E. Boiler Code.

As the writer has many times stated in public, the Boiler Code of The American Society of Mechanical Engineers is intended for the young engineer. Many of our older engineers know all that is in the Code and more, but in looking forward to the future, the writer, for one, is always especially careful in the endeavor to see to it that our young engineers are started correctly.

It is interesting to the writer to review the enormous amount of money spent directly and indirectly by the engineers having to do with the standardization of boilers in America. It was stated authoritatively in New York at the completion of the A.S.M.E. Boiler Code, Issue of 1914 with Index, that the work, if paid for at ordinary professional rates, would have cost at least a quarter of a million dollars.

[1] Deceased.

Further, it was stated by a member of the Boiler Code Committee in New York recently that by the time the Code is universal in the United States, the cost will approximate a million dollars.

To promulgate the Boiler Code throughout the Union, a group of public-spirited citizens organized what is known as the American Uniform Boiler-Law Society, the officers of which are:

Thomas E. Durban, Chairman Administrative Council.
E. R. Fish, American Boiler Manufacturers' Association.
H. P. Goodling, National Association of Thresher Manufacturers.
F. W. Herendeen, National Boiler and Radiator Manufacturers' Association.
M. F. Moore, Low-Pressure Steel Boiler Manufacturers.
I. Harter, Jr., Water-Tube Boiler Manufacturers.
John H. Wynne, Locomotive Manufacturers.
Walter Plehn, Steam-Shovel Manufacturers.
H. N. Covell, Hoisting-Engine Manufacturers.
Chas. S. Blake, Boiler Insurance Companies.
John Hunter, National Electric Light Association.
D. J. Champion, Boiler Materials.

The Chairman states that this organization has expended on an average $1000 per month since starting on the work of interesting the States to adopt the A.S.M.E. Code. This money is being spent to bring the Code prominently before the people and to explain the advantages accruing from its use.

On December 4 and 5, 1916, the American Boiler Code Congress was held at Washington, D. C., at which the official representatives of twenty-three states were present, and it was unanimously voted to approve the Boiler Code of The American Society of Mechanical Engineers.

We also had a very able sponsor from Toronto, Canada, in Mr. D. M. Medcalf, Chief Boiler Inspector of Ontario, who is fully alive and awake to the advantage of having the same Code in force in the Canadian provinces as in the United States.

The writer would mention that whatever assistance he has given to this work has been given in the spirit of true Americanism: to wit, "for the good of the service"—and incidentally this service has been of great educational value to him. He has made acquaintances everywhere and a great many friends in the pursuit of this work and has had the pleasure of acting as Chairman of The American Society of Mechanical Engineers' Boiler Code Committee since its inception.

For those who do not know, the idea of standardization is strictly American, being an American creation; for instance, the standard fire-hose coupling, the standard berry basket, the standard electric-lamp socket, the standard cement specification, standard structural shapes, standard screw threads, and of late, the standard ship and the standard aeroplane engine; and a standard boiler construction using one standard of boiler materials and accessories would naturally appeal to the highest and broadest type of business men in the spirit of maximum conservation and efficiency.

For the states which have not adopted a standard, the only work that is necessary is of an educational nature; for, when the entire case is fully explained, the Code is usually adopted. To those states which have not adopted the A.S.M.E. Code, the writer would recommend its adoption as being the most complete boiler law of any in existence at the present time.

Further, a permanent committee has been established by The American Society of Mechanical Engineers for adding to and deducting from the A.S.M.E. Code as the art advances, and also to assist in the interpretations of the Code in states and municipalities where the engineers are not conversant with its rulings. In other words, The American Society of Mechanical Engineers very advisedly puts itself in the position of a "clearing house" for boiler engineering.

The writer's thought has always been to have the Code so complete that all that was necessary in ordering boilers was to name the type, amount of heating surface required and the working pressure desired, and where credits and reputations were good, a postal-card order might suffice, since the fact that a boiler had been properly stamped with the symbol of The American Society of Mechanical Engineers would be positive proof that all the purposes of the contract and every detail of the Code requirements were fulfilled.

The A.S.M.E. Code is the result of the combined ideas of several thousand engineers who have assisted the Committee from the start up to the present time in producing the right recommendations.

The Code is now under its first revision and the revised printing will be ready for the public within a few months. The proposed revisions are being published from time to time in The Journal with the idea that all those interested be given an opportunity to discuss them before they are brought to their final form for adoption. The greater part of the revisions will be made to clarify the text but not to change the intent of the original Code.

The writer has often been asked how many boilers there are in America, to which he would answer that as near as he can glean there were about 600,000 power boilers in 1914. He would also state that the boiler business in America is said to amount to $500,000,000 per year.

In closing, let it be said that it is the earnest wish of the writer that all those not conversant with the Code may become so, and may assist in putting it into general service at the earliest opportune time. He also wishes to thank all those who have assisted in any way in the promulgation of the A.S.M.E. Standard.

John A. Stevens.

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York City.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in The Journal, in order that any one interested may readily secure the latest information concerning the interpretation.

Below are given the interpretations of the Committee in Cases Nos. 158, and 167-172, inclusive, as formulated at the meeting of July 27 and approved by the Council on August 15, 1917. In this report, as previously, the names of inquirers have been omitted.

CASE NO. 158

Inquiry: Is it permissible under Par. 331 of the A.S.M.E. Boiler Code to omit the stamping from tube heads of boiler drums where they are so flanged and corrugated, as shown in Fig. 1 that the original stamping cannot be preserved, or would it be allowable to stamp the heads with lot numbers as they come off the press so that they may be identified afterward?

Reply: It is the opinion of the Committee that the construction shown is classed with headers and does not require the stamp to be visible after the part is formed.

CASE NO. 167

Inquiry: Can some allowances be made by the Boiler Code Committee in the specifications for steel castings in the Boiler Code, with regard to the chemical composition of the ladle analysis, to compensate for the difficulty at the present time in obtaining castings low in sulphur and phosphorus?

Reply: The matter of modifications in the specification for steel castings has already been referred to the American Society for Testing Materials, and the question is up for consideration at this time, but no decision has been reached.

CASE NO. 168

Inquiry: Referring to Case No. 113d, are we to understand that all plates forming any part of a boiler, no matter

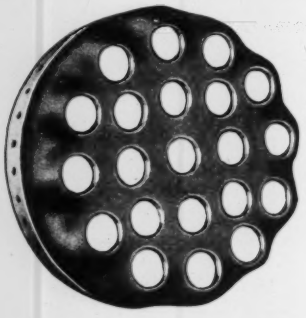

FIG. 1 FLANGED AND CORRUGATED TUBE HEAD

whether they are used flat, bent, or flanged, either hot or cold, must be finished on all edges by either planing, milling, or chipping?

Reply: The word "calking" was inadvertently omitted from the reply in Case No. 113*d*, and the inquiry is answered by the reply in that Case which should read as follows:

> *Inquiry: d* Is Par. 257 intended to do away with the bevel shear for finishing the calking edges of plates, and does it mean that the plate edges may only be planed, milled or chipped?
>
> *Reply: d* According to Par. 257 of the Code, in order to eliminate the incipient cracks left by shearing, the *calking* edges of the plates must be finished by planing, milling or chipping, whether they are sheared straight or beveled.

CASE NO. 169

Inquiry: Can a check valve where a valve stem is provided to permanently close the valve when the stem is screwed down, and thus form a combination stop and check valve, be regarded as both a stop valve and a check valve as required by Par. 317 of the Boiler Code? A device of this character is commonly applied to feed connections on one type of water tube boiler. Is it necessary where this fitting is used on the feed connection of a boiler set in battery to provide such connection with an additional check valve and a globe valve between such check and the source of supply?

Reply: It is the opinion of the Boiler Code Committee that this combination check and stop valve should be classed only as a stop valve.

CASE NO. 170

Inquiry: Can staybolt iron made from hammered blooms consisting of wrought iron horseshoes, be considered as meeting the requirements of the specification in the Boiler Code for staybolt iron, if the horseshoes are originally made from puddled iron?

Reply: It is the opinion of the Committee that Pars. 139 and 140 in the specifications for staybolt iron require that the material forming the box pile shall consist of bars the full length of the pile. If the horseshoes which are used are first worked into the bars described in Par. 140*b*, then cut to the necessary full length and made into the box pile as described, the material will meet the specifications. It is essential that purchased scrap be eliminated.

CASE NO. 171

Inquiry: Is it essential that the 10 per cent limit of variation allowed in Par. 285 of the Boiler Code for the springs of A.S.M.E. Standard Safety Valves, be met where it entails serious hardship to obtain springs so close? Certain manufacturers supply only three springs for the entire range from 25 to 250 lb.

Reply: It is the opinion of the Committee that this is a matter to be taken up with the particular valve manufacturer in question, as the variation called for in the Code can be and is being met.

CASE NO. 172

Inquiry: a Is it to be understood from Par. 296 that ordinary commercial iron or steel pipe may be used from the steam space of a boiler to the upper connection of the water column and that the connection from this pipe to the steam gage may be made of copper pipe?

b Is it permissible under Pars. 320, 321, and 322 of the Boiler Code which require the water connections to water columns to be made of brass and provided with a cross to facilitate cleaning, to connect a drain pipe into one unused opening of the cross and insert a cast iron plug in the other?

c Relative to the arrangement of connections indicated in Inquiry *b*, is it allowable under Pars. 320, 321, and 322 of the Boiler Code to use a malleable iron bushing and a commercial iron or steel pipe to which the drain valve may be connected?

Reply: a This understanding of the requirement of Par. 296 is correct.

b The Boiler Code requires a brass connection from the boiler to the water column including the cross. Any other part can be as described in the inquiry.

c The arrangement described would be considered as in accordance with the Code.

According to *Motorship*, there has been considerable discussion in the last year in regard to the feasibility of concrete ships, and now an experiment is to be made and an ocean-going vessel of large size, in this material, is to be thoroughly tried out. Plans for the ship have been prepared by Leroy Caverly, a marine engineer of San Francisco, and if tests now under way are successful, work on the vessel will shortly be commenced. As planned, this experimental concrete ship is to be 300 ft. over all, 46-ft. beam, with a depth of 24 ft., and be 5000 gross tonnage and powered by steam turbines of 2500 hp. It is claimed that such a craft will have a dead weight no greater than a wooden vessel of the same size, and can be completed in ninety working days at a cost of only $64 a ton. It is not probable that power will be installed at once, but the hull will be towed on a test sea trip.

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1917 and in the March, 1917, issue of The Journal.

SOCIETY AFFAIRS

A Record of the Current Activities of the Society, Its Members, Council, Committees, Sections and Student Branches; and an Account of Professional Affairs of Interest to the Membership

THE Secretary is frequently asked what the Society is doing in connection with the war, and he is happy to say that the Society is not only individually rendering a special service, but it is also coöperating with the other societies in most constructive work. It might be well to here review the several activities of the Society which have bearing on the war situation, but before doing so it should be mentioned that the special activity now occupying our attention to the greatest degree is the work of the Engineering Resources Committee, Mr. George J. Foran, Chairman—that of furnishing specialists for the numerous demands of the Government and the industries generally.

Our circular letter to the membership enclosing the Personal Classification Blank has brought in to date over six thousand replies, and upward of four thousand of these have been collated in the most complete manner. To carry out this work of collation the systems employed by the universities in similar work, by the insurance companies, the Census Bureau and the Bureau of Mines, were all carefully studied and all their good features incorporated in our own system of classification.

The Society is now furnishing names literally by the hundred in response to numerous requests for men familiar with munitions work and with researches in the widest variety of war subjects. One recent letter from Washington opens: "Our Bureau has been asked to assist in getting about one hundred of the very highest-class men having business and executive experience. These men are needed to go to France immediately to take charge of organizing ———. Please send the names and experience of any men who satisfy our requirements and who could go." Another letter from an important committee in Washington begins: "We shall consider it a favor if you could give us the names of as many as fifty mechanical engineers who meet the specifications presented in the enclosed bulletin. We should like not only the names but any ratings which you have adopted in your classification."

A further corroboration of the large number of calls being made on the Society for men is furnished by a study of the columns of the Employment Bulletin in this and the last issues of THE JOURNAL. The Positions Available section of the Bulletin last month was the largest we had ever published. This month's Bulletin is even larger than last month's.

To those members who have patriotically offered their services to the Government through the medium of the Society's Engineering Resources Committee, but who have not yet been rewarded by the assigment to duties under the Government, we can only say that their names have invariably been forwarded and that in due time, as the demand for their particular kind of service is created, the Government will undoubtedly take advantage of it.

Passing in review over the steps the Society has taken in connection with the war situation, it is interesting to state: First, the Committee on Engineer Officers' Reserve was directly responsible for the inclusion in the Hay Bill of 1916 of what is known as the Engineer Officers' Reserve Corps.

Second, the Military Engineering Committee of the Engineering Societies participated in the Preparedness Parade, in New York City, in which 10,000 engineers marched; this committee also conducted a series of lectures on Military Tactics by officers assigned by the War Department, and, further, it recruited an entire corps of 1167 men, plus about 160 others, which has already been sent to France. The expense contributed individually by twenty or more members of the Military Engineering Committee was over five thousand dollars.

This Society also took up energetically at the Spring Meeting in Cincinnati, in May last, the matter of Standardization of Gages, and an officer of the Society went to Washington and discussed the case with some of the Bureau heads, and we have reason to believe that this helped in the passing of an act providing for the work now being developed in the Bureau of Standards.

We have also a General Engineering Committee of the Council of National Defense, and the American Engineering Service Committee and War Committee of Technical Societies of the Engineering Council.

In another column the membership will be delighted to read of the prospective meetings in the West which will be attended by the president. It is a noteworthy occasion when an engineering society can obtain a visit from its president. Dr. Hollis is sacrificing both time and strength to make this tour. It is also a source of satisfaction to announce that Mrs. Hollis will accompany him.

CALVIN W. RICE,
Secretary.

Amendments to the Constitution

The following amendments to the Constitution are to be presented at the Annual Meeting, to be held in New York, December 4 to 7, 1917.

Portions in brackets show additions to the present wording of the Constitution, and portions in parentheses show deletions.

These proposed amendments were approved by the Council, presented at the Spring Meeting at Cincinnati, 1917, for discussion, and under the requirements of C57 and C58 will be presented for final vote by letter ballot.

C26 The affairs of the Society shall be managed by a board of directors chosen from among its Members, Associates and Associate-Members, which shall be styled "The Council." The Council shall consist of the President of the Society, who shall be the presiding officer, six Vice-Presidents, nine Managers, the Treasurer, and the five surviving Past-Presidents who have last held office. [The number of persons constituting a quorum of the Council shall be determined by the By-Laws.] The Secretary may take part in the deliberations of the Council, but shall not have a vote therein.

C45 The Standing Committees [of Administration] of the Society (to be appointed by the President) shall be:

(1) Committee on Finance
(2) Committee on Meetings [and Program]

(3) Committee on Publication [and Papers]
(4) Committee on Membership
(5) [Committee on Local Sections]
(6) Committee on Constitution and By-Laws
(Library Committee)[1]
(House Committee)[1]
(Research Committee)[1]
(Public Relations Committee)[1]
(Committee on Standardization)[1]

[The appointment, organization, duties, and terms of service of Standing Committees shall be as the By-Laws provide. The Chairman of each Standing Committee shall have a seat in the Council of the Society but no vote.

There shall be other standing committees of the Society as the By-Laws provide and the Council approves.]

C47 The Annual Committees shall be:
An Executive Committee, appointed by the Council;
A Nominating Committee, appointed by the President;
Tellers, as required by the By-Laws, appointed by the President;
[Such other committees as may be required from time to time.]

C55 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings. Matters relating to [partisan] politics or purely to trade shall not be discussed at a meeting of the Society, nor be included in the Transactions.

C56 The Society shall not (approve or adopt any standard or formula, or approve any engineering or) [endorse any] commercial enterprise. It shall not allow its imprint or name to be used in any commercial work or business.

C58 The letter-ballot, accompanied by the text of the proposed amendment, shall be mailed by the Secretary to each person entitled to vote, at least thirty days previous to the closure of the voting. The ballots shall be voted, canvassed, and announced as provided in the By-Laws. The adoption of the amendment shall be decided by a majority of the votes cast. An amendment shall take effect on the announcement of its adoption by the Presiding Officer of the Semi-Annual Meeting next following the closure of the vote. [Any changes in the order of consecutive numbering of existing articles of the Constitution, made necessary by such adopted amendment, shall be made under the direction of the Council.]

[1] To be designated Standing Committees, in distinction from Standing Committees of Administration, and to be provided for in the By-Laws.

A LOOK AHEAD

A Review of the Prospective Work of the Society for the Coming Year

HUNDREDS of calls are coming to the engineering societies of the country for help and coöperation in meeting the needs of the war. Highly-trained men are wanted in large numbers, besides technical advice and information on innumerable subjects. In all such work concerted action is necessary and the avoidance of duplication; hence the importance of the Engineering Council and its War Committees, representing collectively the several engineering societies as described by President Hollis, Chairman of the Council, elsewhere in this number.

In a look ahead the greatest promise for effective service to the Government by the Society appears to lie in the part which it will play in this united service by the engineers of the country.

Acting as a separate unit, however, the Society has already done enormous work in this direction largely through its Engineering Resources Committee, George J. Foran, Chairman, which has classified and indexed with respect to their specialties 4000 members and hopes eventually to have similar data for every member to use in supplying the war needs of the country.

DEVELOPMENT OF THE SECTIONS

Last year five new sections were organized at Baltimore, Detroit, Erie, Indianapolis and New Orleans, making a total of 21 sections. The Committee on Sections recognizes that these local organizations emphasize the national scope of the Society and intends to continue this development by the addition of several new sections besides the organization of the Connecticut Section with its five branches, announcement of which has already been made.

This organization of state sections is of more than passing interest. The Minnesota Section was the first and the Atlanta Section has aimed to administer to the requirements of several of the Southeastern group of states, but Connecticut is the first state to have a number of Branches holding meetings in their respective localities, and all contributing in addition to the development of the Society throughout the state. The plan of organization is explained more in detail under another heading.

It is the purpose of the Sections Committee to encourage the sections to identify themselves with local, civic and municipal affairs inasmuch as they relate to engineering projects. An effort will also be made to obtain united action by the several sections on work proposed by the various standing committees of the Society: as for example, if the Research Committee were to outline a series of investigations it is thought that they would be much more successful if the local sections joined in the conduct of the work.

The sections benefit the membership at large by the publication of the section papers in THE JOURNAL. The committee has therefore suggested as a uniform practice that each local section make a special effort this year to contribute technical papers and data, through the establishment of the following organization:

1. The appointment of a committee of three, particularly qualified, to study the local field and determine what papers and data the section is best qualified to contribute; solicit the contributions of papers from local engineers and report to the Committee on Sections. Attention is called to the fact that papers need not be long. In fact, brief, concise statements of valuable information often are of interest and value.
2. Select a committee of two, qualified by broadness of vision, to investigate what researches may be most effectively carried out because of the particular engineering work being done in the locality. Appoint those particularly fitted to organize and conduct these researches and report the findings to the Committee on Sections.

   These researches need not necessarily be in the nature of obtaining original data but may be reports of progress or achievements made in any branch of the profession or consist in the arrangement in convenient form of the best information available on any particular subject. Good technical reports on local engineering developments will also be excellent material.

   There are many well-qualified young men in each locality who will be glad to undertake to accomplish the results if properly encouraged.

It has been suggested that this organization be effected at once in order that one of the first meetings this fall may be given over to the promotion of these results.

In accord with the plan previously announced to have the sections brought into closer contact with the activities of the Society, the Committee on Sections will visit the St. Louis, Milwaukee, Chicago and Detroit Sections this month for the purpose of acquainting those sections with the needs of the Society as outlined in the preceding paragraphs.

In connection with the work of the sections it is pleasing to note that the members at Seattle, Wash., and Portland, Ore., have invited President Hollis to visit them, and for the first time in the history of the Society the members of the Society in those Northwestern cities will come together at a meeting held under its auspices. This will indeed be a momentous occasion and it is fitting that the President of the Society should be the guest of honor. It would not be surprising should the organization of a section in that locality result because of the spirit and enthusiasm which Dr. Hollis brings to all those who have the opportunity of hearing him promulgate his doctrines on the opportunity of the engineering profession to take a leading part in making the world a democracy.

MEMBERSHIP WORK

The work of the sections is closely allied to that of the Committee on Increase of Membership because it is the latter which often makes possible the establishment of a section by securing the strength in numbers to make possible successful meetings. The committee plans to continue during the coming year its established policy of conservatively encouraging the members of the Society to bring within the pale of its influence all mechanical engineers of proven ability and to continue the acquaintanceship work at meetings which it has conducted in the past. The present membership is over 8200.

STANDING COMMITTEES

The Finance Committee has prepared its budget for 1917-18, including a report for the past year, showing that the annual income has passed the $200,000 mark. Next year it is estimated to reach $228,500. In preparing the budget the usual plan is followed of providing for only 90 per cent of the expected income and for half of the initiation fees to be placed in the reserve fund. As a result of this sound policy, the Society holds an enviable position among other organizations as one of unquestioned strength and stability and prepared for any call upon its resources which is likely to arise.

The Committee on Meetings, which has conducted in the past year what are generally considered to have been the two most successful conventions of the Society, has plans well developed for the coming Annual Meeting, elsewhere outlined. Of the sub-committees, the Committee on the Protection of Industrial Workers has now under preparation a number of safety codes including codes for elevators, machine-shop guards and woodworking-machinery guards, which they hope to bring before the Annual Meeting in December.

The Publication Committee has rounded out the year with THE JOURNAL covering the mechanical engineering field through its reports of meetings of the Society and reviewing the engineering press more thoroughly than ever before. New departments have been added, the circulation is now considerably above 10,000 and the advertising is constantly increasing. While no radical changes are expected, it is intended to maintain this substantial development and growth; and this applies as well to the annual volume of Transactions and the annual volume of Condensed Catalogues.

The House Committee has completed extensive alterations in the Society's rooms. By the removal of partitions better facilities have been provided, the most modern lighting system has been installed, the acoustics have had most careful attention. The office is now located in two large rooms, one devoted to the publication and engineering work and the other to the business and secretarial departments. Later the reception and reading rooms, the Secretary's office and the Council room will be redecorated.

The Committee on Constitution and By-Laws has had under consideration for some time a number of amendments necessitated by the growing membership of the Society and the larger demands by other societies and the Government upon its facilities. A complete report of these amendments will be found in another part of this issue of THE JOURNAL.

TECHNICAL COMMITTEES

The Standardization Committee expects to continue its work in connection with the American Engineering Standards Committee. This committee has drawn up a constitution, and deems this to be only the beginning of what is hoped will eventually fill a very important national and international need. It is expected that with time there will be found to participate in the work of this committee every technical association or society whether of an engineering or other nature, not only in the United States, but abroad. A beginning in this direction has already been made in that the British Engineering Standards Committee has invited this American Engineering Standards Committee to send delegates to London to consider a change in the British standard Whitworth thread to the simpler cross section of the United States screw thread and to consider also the question of metric threads.

The Boiler Code Committee has the following program under consideration for the coming year:

The completion of the first revision of the Boiler Code, in pursuance to a recommendation which was accepted by the Council of the Society and which was as follows:

"Your Committee recommends that you appoint a permanent committee to make such revisions as may be found desirable in these Rules, and to modify them as the state of the art advances, and that such committee should hold meetings at least once in two years at which all interested parties may be heard."

The regular monthly meetings of the committee will be held for the purpose of considering communications relative to the Boiler Code and rendering interpretations thereon.

The Committee on Flanges and Pipe Fittings has the following topics: A 50-lb. low-pressure standard for steam, water and air, etc.; a 600-lb. standard for superheated steam; 800, 1200 and 3000-lb. standard for water, air, gas, etc., with ratings proportionate to shock or no shock conditions. Malleable iron pipe fittings and unions are also scheduled for the Committee's consideration.

The A.S.M.E. and the Manufacturing Standardization Committee have been working jointly in the compilation of drawings, tables and data, most of which should be available for the committee's discussion during the coming years.

The Research Committee has several sub-committees which have investigations or reports in process, outlined in what follows.

Lubrication: Research on cylinder lubrication under both steam and gas engine conditions is expected to be undertaken by Professor Flowers of Ohio State University. This

work will require an appropriation of $600 for the ensuing year to carry it through. The apparatus has been especially built for the purpose and is the only one of its kind in this country.

Cutting Action on Machine Tools: In conjunction with the Bureau of Standards, this committee is to carry out an investigation of the stresses and conditions involved by change in shape and material, cutting speed, etc., on a special planer equipped with dynamometer at the Bureau of Standards. An investigation is also to be undertaken on the action of the De-Leeuw rotary cutter, which gives a very large increase in cutting capacity over the old type stationary tools, using the same materials. This work should prove very valuable from a production point of view and therefore would appear to be of considerable interest to the Government in connection with munitions work.

Worm Gearing: This committee has prepared a study of the important American patents on the subject of bearing metals and expects to make a study during the following year of the foreign patents also. It has in view to collect all patent data before reporting; it will take at least a year to do this.

Flow Meters: This committee is preparing what is practically a complete text on the theory, formulae, accuracy, cost and desirability of various types of commercial flow meters now on the market. This is being written in six sections, at least two of which will be ready for publication in December.

The general plan upon which all of the sub-committees are working, is that all previous work upon the particular subjects involved should first be collected by means of a bibliography and written up in a compendium, so that reference outside of the report would not be needed. The principal reason for adopting this plan was to avoid the unnecessary duplication of work which so often occurs in committee activities.

Several of the other committees have standardization work under way upon which it is not possible to announce future plans at the present writing. So extensive has become the professional work of the active committees of the Society, however, that the Secretary has under advisement the organization of a department of the office staff to attend solely to the committe requirements.

THE ENGINEERING COUNCIL

THE formation of an Engineering Council is the outgrowth of a real need for proper consideration of questions of general interest to engineers and to the public, and to provide the means of united action upon questions of common concern. Many such questions have come up in the past and will arise in greater number in the future. This war has brought out very impressively the actual need for united action of some kind. At present the Council is concerned only with four societies because that seemed the most practical way of getting a group of men together to answer the immediate needs, but these societies do not assume to speak for all engineering societies in the country. Criticism that they are exclusive in any way is utterly mistaken. There is the hope that such a Council by proving itself effective may lead to much wider coöperation in a strictly representative body for all engineers, and thus pave the way for a very much larger union in the future.

How can the Council be enlarged? By a union of all societies either as the outgrowth of the present Council or by a congress of engineers leading to united action by all societies. The first method will be the most natural one because many local societies and national societies also have a large membership in the four societies at present concerned. We have three classes of engineers to reach: First, those who are members of local societies and not members of national societies; second, those who are members of national societies and not members of local societies; and third, those who are members of no society. The last-named class constitutes a very large number in our profession.

We engineers are almost as mixed as American citizenship, and we suffer therefrom just as much as America with a population representing every race and every people in Europe. There can be no question of the enormous advantage of union. That union should be completed by strengthening the existing agencies and not by the formation of new societies. The national societies are thoroughly national notwithstanding an occasional complaint that they are run by New York. If they have not been able to express the democratic spirit of our country as fully as might be desired, it is the fault of the members in all the states and not of the city in which the principal offices are located.

The four societies concerned at present are the American Society of Civil Engineers, the American Institute of Mining Engineers, The American Society of Mechanical Engineers and the American Institute of Electrical Engineers. They have come together from time to time in the past for special purposes and there have been general conferences on subjects requiring immediate settlement, but until the Engineering Council was definitely organized in June there was no permanent body to advise all the societies. We have had many fruitful discussions in the past leading to useful action. The Standardization Committee which has been organized to represent five societies has passed upon commercial standards of all kinds. This committee has great possibilities and it should be enlarged enough so that its influence may become very widespread.

Many problems have already been presented before the Council. Its personnel, made up of twenty-four men representing equally the four societies, is well-balanced and judicial. The first duty was necessarily the organization and appointment of standing committees, which have already been reported in the press. They might with advantage be mentioned here:

1 Committee on Public Affairs, comprising Messrs. C. W. Baker, G. F. Swain, S. J. Jennings and E. W. Rice.

2 Committee on Rules, comprising Messrs. J. P. Channing, Clemens Herschel, N. A. Carle and D. S. Jacobus.

3 Committee on Finance, comprising Messrs. B. B. Thayer, I. E. Moultrop, Calvert Townley and Alex. C. Humphreys.

Certain questions relate, however, to the war and the assistance that engineers can render. A committee to be called the American Engineering Service Committee was appointed with instructions to invite the coöperation of all engineering societies. This committee in the first instance consists of A. D. Flinn of the Civil Engineers, A. S. McAllister of the Electrical Engineers, George J. Foran of the Mechanical Engineers, G. C. Stone of the Mining Engineers, and E. B. Sturgis of the Mining and Metallurgical Engineers. Its present duty is the tabulation and listing of the members of the five societies represented, in order that we, as a profession, may be in a position to take a larger part in the industries

after peace is declared. This tabulation has already in part been done, but in a rather unsystematical and unequal way. It is hoped that the new committee by having additions from other societies may make a final and lasting tabulation of all the engineers in the United States. The list is to be kept in the Engineering Building for general use in Government problems and in the industries. At present the committee is devoting its attention to the immediate need of the hour, namely, the procurement of men for special service in the Government. A list of specialists in the societies has already been completed.

There are three methods by which engineers may enter United States service; first, through some organization; second, through individual application to a department of the Government, and third, through selection by the Conscription Law. But this is war service wholly and not civil service, which is the same now as it has always been. As a matter of fact, a great many engineers have already entered through the engineering societies, through colleges and through various special boards in Washington. The importance, however, of a complete list of engineers and their professional specialties cannot be overrated. Such a complete list can be made only with the help of the local as well as the national societies. The committee mentioned above is organized with George J. Foran as chairman and A. S. McAllister as secretary. All societies should respond to the request for coöperation.

Another committee, of which Harold W. Buck is chairman, is called the War Committee of Technical Societies. The members are Messrs. H. W. Buck, A. M. Greene, Jr., R. N. Inglis, C. R. Corning, G. C. Stone, D. W. Brunton, J. M. Boyle, J. V. Davies, Joseph Bijur, A. S. McAllister, W. D. Richardson and Charles Baskerville. It was appointed to assist any organization in Washington, such as, for instance, the Council of National Defense, the National Research Council and the Naval Consulting Board, in any way in which it can bring to the attention of the engineers of the country the necessity for thought and help in the numerous problems that arise.

A Council organized by the enlargement of the present Engineering Council can be very effective in many ways without interfering with the autonomy of any individual society. Every society has some definite purpose of its own and also some which it holds in common with all other societies. One of the latter purposes relates to public service and to coöperation. To the end that all societies may understand fully their opportunity, the committee of which Mr. Foran is chairman has made a complete list of all the societies and their officers, and communications are being sent out inviting coöperation; and it is hoped that the Council may be successful in arousing sufficient interest to bring about a larger and better Council for all engineers.

In organizing the Council, provision was made for the election to membership of other national engineering and technical societies. There is no doubt that rules can be made under which these societies may become members, but this will involve consultation and discussion in the future.

The office of the Council is in the Engineering Societies Building, 29 West 39th Street, New York City.

(Signed) IRA N. HOLLIS, *Chairman*,
Worcester, Mass.

CALVERT TOWNLEY, *Secretary*,
115 Broadway, New York City.

THE COMING ANNUAL MEETING

THE time is past when engineers, citizens of a country at war, can with equanimity sit in convention to discuss details of engineering practice. Their thoughts are on the great problems of the war and on the service which they can render their country.

With this in mind the Committee on Meetings has planned a program for the Annual Meeting which is designed to be of definite and constructive value for those in the service of the Nation. While a sufficient number of excellent technical papers will be provided on general subjects to uphold the standard of the Society's Transactions for reference purposes, emphasis will be placed on a series of addresses to be given on some of the broad problems that now confront the engineer in his endeavor to give his country the mastery in the great struggle which is to make the "world safe for democracy."

On Tuesday evening will be an address by Hon. Wm. H. Taft, former President of the United States, and conferring of honorary membership on Maj.-Gen. Geo. W. Goethals, events of the greatest interest and satisfaction to every member.

The business meeting on Wednesday morning will be followed by a session in charge of the Committee on Local Sections. The importance which the Sections have assumed in the Society and the possibilities they offer for a broadening influence in the Society's affairs have led to the assignment of this as the opening session, and a very full discussion of the topics to be presented is hoped for.

An intimate account of the engineering achievements of the late Mr. E. D. Leavitt will be presented by Mr. F. W. Dean.

All are agreed that to win the war there must be conservation of resources, including food, fuels and supplies of all kinds; higher efficiency in industry and transportation; unlimited production of munitions and appliances of war; willing coöperation on the part of every citizen, regardless of his status in life; and the greatest possible development of American inventive and productive talent.

The question of the solution of such problems as the foregoing will form the basis of the keynote session on the general subject of Service of the Engineer to the Public. This session will last all day Thursday, December 6, and will be opened by President Hollis who will speak on Universal Public Service in Peace and War. He will be followed by other speakers treating of the topics given below:

The Agricultural Machinery Problem.
Topical Discussion on Machinery of Food Production.
Railroad Transportation.
Motor Transportation.
The Aircraft Problem.
Topical Discussion on Aviation.
Special Education in Time of War.
Engineering Research.
Building a Merchant Marine in a Hurry.

Certain of the foregoing subjects, notably Agricultural Machinery and Aviation, will be discussed in detail, with papers on steam, gas and electric power on the farm, farm transportation and the machinery of canning and preserving. In the case of the aircraft problem there will be discussed the

selection and training of aviators, and problems of aircraft engineering and aircraft production.

At the Cincinnati meeting last spring the three sessions on the principles involved in the manufacture of munitions were among the most enthusiastic and largely attended meetings ever held by the Society, with members in attendance from all sections of the country and Canada. In order to carry this work further a session has been arranged for the Annual Meeting by the Sub-Committee on Machine Shop Practice, upon the subject of inspection. At this session an attempt will be made to present, on the one hand, the requirements of the Government, and on the other, the difficulties encountered by manufacturers in interchangeable manufacture, with the object of defining as far as possible the philosophy of inspection and offering constructive suggestions for carrying out its underlying principles.

Two other sessions by sub-committees have been arranged, one by the Sub-Committee on Textiles and the other by the Sub-Committee on Air Machinery. The former, like the session on the subject of inspection, will deal with broad principles applicable alike to textile manufacture and to other lines of industry, two of the topics being questions of labor turnover and safety in textile mills.

Another timely subject under the present condition of affairs where manufacturers are working under tremendous pressure is that of industrial management and methods of increasing production. There will be a session on management at which one topic, a comparatively new one, will relate to the employment of women in the skilled industries, with special reference to machine-shop and heavy work. Bearing on this also will be addresses on the relation of industrial management to the engineer, to indicate the broadening field of the engineer and the extent to which his efforts must lie in the direction of the management of men, both in respect to efficiency and to social service. It is hoped that arrangements can be made for a luncheon for the membership on one day of the convention at which certain of these matters will be discussed in after-luncheon addresses.

It is expected further that Dr. Brashear will be with his friends of the Society again and deliver the lecture on the Beautiful in Commonplace Things which he was to have given last year, but was prevented from doing by his trip to the Orient. This lecture will be as an oasis in a desert in these war times when we are prone to forget that there are larger, higher and more important things in life than strife among nations.

As for the past two years, there will be a smoker on Wednesday evening for the membership and while the program has not been definitely concluded, several members have expressed the desire that Past-Presidents John R. Freeman, Ambrose Swasey and John A. Brashear may be prevailed upon to tell at that time some of the incidents of their trip to the Orient during the past year. Nothing, surely, could be more pleasing to everyone than this.

WAR CONVENTION OF AMERICAN BUSINESS

Chamber of Commerce of the United States of America, Atlantic City, N. J., September 17-21

THE program of the great convention of American business, just held at Atlantic City, was representative of all walks of life—cabinet officers, captains of industry, engineers, bank and railroad officers. Never has the Secretary attended a meeting from which emanated so impressive and vital a message for the engineers of the country who are holding the pivotal points on the firing line of industry. In some small measure the Secretary desires to pass on the message to every member of the Society.

The earnestness of the speakers and the seriousness of the situation in which the country finds itself at the present time were emphasized throughout the meeting. All the resources of the nation's business were whole-heartedly and unreservedly pledged to help win the war. *This includes us!*

It would be impossible to portray the fervor of the convention, and in the space available in THE JOURNAL no more than an outline can be given of the more important addresses. Those desiring a complete statement may obtain it in the next issue of *The Nation's Business*, published monthly by the Chamber of Commerce.

The addresses covered in the following notes are those of President Rhett, Secretary of War Baker, the Secretary of the Interior, Mr. Lane, and the Russian Ambassador, given Tuesday; those of President Bedford of the Standard Oil Co., Park President Harry A. Wheeler, Mr. Herbert C. Hoover, Mem.A.I.M.E., and Lord Northcliffe on Wednesday; and those of the Secretary of Labor, Mr. Wilson, and Mr. L. A. Osborne, Mem.Am.Soc.M.E., on Thursday.

The chairman of the Munitions Board, Mr. Frank A. Scott, Mem.Am.Soc.M.E., was absent on account of illness.

President Rhett said:

"The Chamber has not only called together the delegates from its own 950 commercial organizations' members, representing over 400,000 individuals, firms, and corporations, and its own individual and associate members numbering over 6000, but it has extended invitations to other commercial organizations of the country not members of the Chamber, to be represented here, and to unite with it in sending out a message from the business men of America which will let the world clearly understand that whatever the cost, whatever the sacrifice, they propose to place every resource at their command behind the Government, and its Allies in their determination to see that liberty, democracy, civilization, and humanity shall not perish.

"There may be those who would sacrifice any national welfare, present or future, to their own ambitions, possibly to their own comforts, but, thank God, in this splendid democracy of ours, they can constitute a very small minority, and in the ranks of business their number is negligible. Let us make this number infinitesimal by such vigorous pronouncements and by such united action both in convention assembled and in business engaged that every impulse to selfish or sordid action may be suppressed and a great wave of enthusiasm may move us on to such achievement in service and in sacrifice as shall constitute a compelling influence for a speedy conclusion to this war—a conclusion that will bring us a real peace—a peace for this generation and generations to come—a peace that will secure for all times to mankind its most precious possessions which in their aggregate we call civilization and humanity."

Secretary of War Baker struck the keynote of the conference when he declared at the morning session:

"American business has been at the right hand of the Government since the moment war was declared. We want every man that can be influenced by you, every woman, and every child enrolled in another great army, the army of American business."

Secretary Baker's speech was intensely human and forceful, and was so clear-cut and compelling that when he had finished he had given the big business men in attendance a clear idea of the reasons why business and the Government had at times been wide apart, and why they were now so closely welded together in a common cause.

Secretary Lane's speech was the feature of the afternoon session on Tuesday, and the audience, estimated at three thousand, cheered him again and again as he recounted the situation. Among other things he said:

"We of America, it is conceded, know how to make money, and we will prove that we know how to make war, wholehearted, resolute war, war that means organization, machinery, science, war that means men by the million and money by the billion, war that means heartbreakings, ruined hopes, a little glory perhaps, a certain self-respect, a world that men can grow in.

"If there is a danger in this country it is not that our men will not be brave, that our guns will not be great, that our troops will have no ammunition and our generals no strategy, but it will be the danger coming from discontent with domestic conditions. The business man can prove his loyalty most surely in fixing prices, in marking down the shoe lace, the loaf of bread, the hatchet, the coat, the beefsteak, all the commonplace things of life, than in any other way. There is not a business man in this hall who does not carry in his hand the future of this war."

The evening session was opened by an address by Charles Edward Russell, who was a member of the Root Commission recently returned from Russia.

He impressed his audience with the seriousness of the situation by emphasizing that

"A thin Russian line of soldiers is all that stands today between the Kaiser and his goal; all that stands between the principle of freedom and the triumph of autocracy. There are upon the Russian line from Rumania to Riga, 153 army divisions. Upon the entire French front there are only 123 German divisions. Let Russia collapse and the German flood will sweep aside anything of resistance that is now there. The Russian people are self governed and they look to us as their brothers. Instead of being bankrupt, they are the richest people on earth, richest in natural resources, richest in character.

"This is our opportunity to save the nation. Let us give freely. Let us show to them that we are really a United States and that we will fight for freedom to the end."

The Russian Ambassador, after a complete statement of conditions, exclaimed:

"What Russia needs most of all is improvement of railway transportation, reorganized agricultural production and a diligently executed possible restitution of supply of general commodities, whether manufactured within the country or imported. Railway materials of all kinds and primarily rolling stock machinery for repair; agricultural implements; machine tools, instruments and raw materials for improving the production within the country; certain commodities of everyday life, that is what Russia needs and needs badly. And, gentlemen, for these requirements to be fulfilled, outside of credits, she needs ships, ships and ships."

President Bedford of the Standard Oil Company urged both economy and increase of production, giving statistics to show the inadequacy of the present supply.

The most eloquent words of the entire convention was the peroration of Past-President Harry A. Wheeler, chairman of the Chamber's Committee on Transportation. He predicted federal control of railroads.

Thursday evening Herbert C. Hoover warned the nation of the penalty of failing to aid the Government, and that inability of business men to realize their responsibilities and coöperate adequately with the Government might result in socialism.

Speaking of Russia, he said:

"Justifiable as this revolution may have been and as great a cause of liberty as it may result, no one can deny that the whole trend of this revolution has been socialistic, and the latest phase is a development into practical socialism. The strain in the revolution, I am convinced from much experience in Russia, was the reaction from failure of the Government and the commercial classes to meet their public duty.

"The other end to be attained is of profound importance. The alternative to failure of our commercial system to maintain its place and at the same time serve public interest is rigid autocratic governmental organization of industry of the German type. Such organization is autocracy itself—it breeds beaurocracy and stifles initiative, and thus democracy, at its birth. We mus organize—we must mobilize our every national energy, if we are to win this war against the organization perfected by autocracy. Either we must organize from the top down or from the bottom up. One is autocracy itself—the other, democracy. If democracy cannot organize to accomplish its economic, as well as its military defense, it is a false faith and need be abandoned."

These are momentous words.

Lord Northcliffe, the head of the British mission, followed with a tribute to the ability and bravery of Mr. Hoover. He further prefaced his remarks by stating that he was engaged in directing one of the largest businesses in America, that of expending $50,000,000 per week.

He went into the exact details of the war as it pertains to us. The following is an example:

"You will require vast refrigerating stores for the preservation of meats and other foods for your armies. At this time six months from now you will probably have between 600,000 and 800,000 men in France. Think of the refrigeration machinery you must establish.

"This war is the greatest business the world ever knew and in our country we are doing nothing else. Let me tell you that you will have to furnish between five and six pairs of shoes a year in the easiest parts of the lines at the front and twelve pairs a year at the hard parts for each of the 600,000 or 800,000 men you will soon have on the front."

Lord Northcliffe pointed out that the average life of a rifle is six weeks as one instance in addition to those already cited of the amount of business organization that must be created in the United States on account of the war.

Thursday morning the third member of the Cabinet to address the meeting, Secretary Wilson, gave a condensed statement of why we were at war, and followed by an exhortation equally to the laboring man and to employers to remember that neither may take this opportunity of the nation's distress to gain advantages that could not be obtained in times of peace, and that the sole idea of all must be to coöperate to win the war.

On Friday the resolutions approved by the Resolution Committee and unanimously adopted by the convention were principally as follows:

"Assembled on the call of the Chamber of Commerce of the United States and representing more than half a million business men and every industry in every state in the Union, this convention promises to our people that business will do all in its power to prevent waste of men and material and will dedicate to the nation every facility it has developed and every financial resource it commands on such terms and under such circumstances as our Government shall determine to be just."

Next to the general pledge to the Government, the most important resolution was the second, which read, in part:

"Be it resolved by the representatives of American Business met in War Convention, that all war buying should be assembled under the control of one board or executive department; and

"Be it further resolved, that this war supply board or department should be given full power to procure war supplies to the best advantage to the Government as to price, quality, and deliv-

ery, and in a way to maintain essential industrial life without disturbing social and economic conditions, including the power to fix prices not only to the Government but to the public on essential products, and to distribute output in a manner to promote the national defense and the maintenance of our industrial structure."

This proposal is one which the members of the chamber, particularly those of them who have had occasion to do war business in Washington, feel most strongly is essential to the efficient prosecution of the war; and while there is variance of opinion as to the reasons for the present confusion, nearly everybody is agreed that centralization is the obvious remedy.

Another most important development which is only beginning—a very promising start has been made in some industries already—was the recommendation that every industry organize a war committee of its leading men to coöperate directly with the Government in finding a way to meet every demand that the Government makes on industry.

It will then be seen that this Society, "The Society of the Industries," is vitally affected by the decisions of this convention and as executives to carry them to a successful conclusion.

CALVIN W. RICE.

Visit by the President

President Hollis will leave Worcester on October 14 for a visit to several Sections and Student Branches of the Society in the far West. His itinerary includes visits to the following cities: St. Louis, El Paso, Los Angeles, San Francisco, Seattle and Portland. Upon the completion of this trip Dr. Hollis will very nearly have accomplished his aim to visit every Section of the Society during his term of office, something which no other President of the Society has been able to do. Wherever Dr. Hollis has spoken, before Student Branches and Sections, he has been uniformly successful in creating unusual enthusiasm.

Including the visits made by the Secretary practically every Student Branch and Section of the Society, numbering 59 in all, will have been visited within the year ending November first.

The following table shows in detail what has been done, H indicating visits by President Hollis and R those made by Secretary Rice:

VISITS OF PRESIDENT AND SECRETARY

SECTIONS		STUDENT BRANCHES	
Atlanta	H 1-17-17	Arkansas, University of	R 4- 9-17
Baltimore	R 10-24-16	Armour Institute of Technology	R 3-31-17
Birmingham	H 1-15-17	Bucknell College	R 10-26-16
Boston	H 2- 7-17	California, University of	H 10-17
Boston	R 2- 7-17	Carnegie Institute of Technology	R 10-16-16
Buffalo	H 3- 7-17	Case School Applied Science	R 10-17-16
Buffalo	R 10-18-16	Cincinnati, University of	R 3-23-17
Chicago	H 1- 5-17	Columbia University	R 12-11-16
Chicago	R 3-31-17	Georgia School of Technology	H 1-17-17
Cincinnati	R 3-23-17	Illinois, University of	H 1-10-17
Cincinnati	H 5-23-17	Iowa, State University of	R 4- 2-17
Detroit	H 1- 3-17	Johns Hopkins University	R 10-25-16
Erie	R 10-19-16	Kansas State Agricultural College	R 10-22-16
Indianapolis	H 3-12-17	Kansas, University of	R 4- 3-17
Indianapolis	R 10-20-16	Kentucky, State University of	R 3-24-17
Kansas City	R 10-23-16	Louisiana State University	H 1-12&13-17
Los Angeles	H 10-17	Michigan, University of	H 1- 4-17
Milwaukee	H 1- 6-17	Minnesota, University of	H 3-10-17
Milwaukee	R 3-28-17	Missouri, University of	R 4- 6-17
Minnesota	H 3- 9-17	New York University	H 3-16-17
New Haven	R 10-15-16	Ohio State University	H 3-13-17
New York	H 3-16-17	Pennsylvania State College	R 10-27-16
New Orleans	H 1-13-17	Polytechnic Institute of Brooklyn	H 3-16-17
Philadelphia	H 3- 9-17	Purdue University	H 1- 8-17
Providence	H 3-28-17	Rensselaer Polytechnic Institute	H 3- 5-17
San Francisco	H 10-17	Throop College of Technology	H 10-17
St. Louis	R 10-24-16	Washington University	R 10-24-16
St. Louis	R 4- 8-17	Washington University	R 4- 8-17
		Wisconsin, University of	R 3-26-17
		Yale University	R 11- 3-16
		Massachusetts Institute of Technology	R 2- 7-17

CANDIDATES FOR MEMBERSHIP

TO BE VOTED ON AFTER NOVEMBER 10, 1917

Below is the list of candidates who have filed applications for membership since the date of the last issue of THE JOURNAL. These are classified according to the grades for which their ages qualify them, and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate or Associate-Member, those in the third class under Associate-Member or Junior, and those in the fourth under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to scrutinize this list with care and advise the Secretary promptly of any objections to the candidates posted. All correspondence in this regard is strictly confidential. Unless objection is made to any of the candidates by November 10, 1917, and providing satisfactory replies have been received from the required number of references, they will be balloted upon by the Council. Those elected will be notified about December 15, 1917.

NOTE. The Council desires to impress upon applicants for membership that under the present national conditions the procedure of election of members may be somewhat slower than under normal conditions. The first step in the consideration of an application is taken by the Membership Committee, and this committee is composed of busy men, with limited opportunity to meet together in these strenuous times.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Alabama

APPLEBY, WILLIAM C., Mechanical Engineer, Southern Wheel Co., Birmingham

JOHNSON, MORRIS R., Chief Field Engineer, Fairfield Works, Tennessee Coal, Iron & Railroad Co., Fairfield

Connecticut

CLARK, JAMES G., Chief Inspector, Remington Arms Co., Bridgeport

HOGAN, WILLIAM E., Superintendent Interior Transportation, Remington Arms U.M.C. Co., Bridgeport

LANE, AUGUSTUS H., Engineer,
The Eastern Machinery Co., New Haven
MEAD, RICHARD R., Assistant General Works Manager,
American Graphophone Co., Bridgeport
SPIERS, FREDERICK G., Superintendent,
B. & K. Mfg. Co., New Britain
WELLS, HERBERT E., Division Superintendent,
Remington Arms U.M.C. Co., Bridgeport

District of Columbia

BRIGGS, CLARK A., Associate Physicist,
Bureau of Standards, Washington

Georgia

ELEY, J. N., Consulting Mechanical and Electrical Engineer,
Atlanta
HUNTINGTON, WILLIAM S., Designing Engineer, Packing Plants and Cold Storage,
C. L. Brooks Engineering Co., Moultrie
HONIKER, CHARLES D., Textile Manufacturing,
Fulton Bag & Cotton Mills, Atlanta
TITSHAW, ERNEST P., Electrician,
Atlanta Water Works, Atlanta
WIKLE, JAMES T., Mechanical Engineer,
Fulton Bag & Cotton Mills, Atlanta

Illinois

FISKE, CLARENCE W., Assistant Chief Engineer,
Williams, White & Co., Moline
KLINCK, FRED E., Mechanical Engineer,
H. Mueller Mfg. Co., Decatur
McDERMOTT, GEORGE R., Steam Engineer,
Illinois Steel Co., South Chicago
SISSON, VINTON E., Assistant to Vice President,
The Pressed Steel Mfg. Co., Chicago

Indiana

LONN, EDWARD J., President,
Great Western Mfg. Co., LaPorte

Kentucky

MEEHAN, JAMES L., Manager, Open-Hearth Steel Plant,
Ashland Iron & Mining Co., Ashland

Maryland

ALLISON, ROBERT P., Works Manager,
Poole Engineering & Machine Co., Baltimore

Massachusetts

BOLTON, FRED C., Chief over Gage Makers and Assistant Foremen,
New England Westinghouse Co., Springfield
BRINCKERHOFF, HENRY G., N. E. Representative,
The Engineer Co. of New York, Boston
FISKE, GEORGE L., Engineer,
Choralcelo Co. of Massachusetts, Boston
ISBELL, JOHN A., Chief Engineer,
Wood Newspaper Machinery Corp., Taunton
MORGAN, EARL B., Safety Engineer,
Norton Co., Worcester
PERELSTROUS, ANANY W., Special Russian Representative,
New England Westinghouse Co., Springfield
PERKINS, HENRY F., Assistant Mechanical Engineer,
Worsted Department, Pacific Mills, Lawrence
SHORT, FRED A., Mechanical Designer and Checker,
Stone & Webster Engineering Corp., Boston

Michigan

DENNIS, BASIL W., Assistant Superintendent of Power,
Ford Motor Co., Detroit
GRAVES, WALTER J., Assistant Engineer,
U. S. Engineer Department, Sault Ste. Marie

Montana

BLAKE, HAROLD N., Assistant Superintendent,
Anaconda Copper Mining Co., Anaconda

New Jersey

HAWKINS, WILFORD J., Vice-President,
International Arms & Fuse Co., Inc., Bloomfield
JACOBSON, CONRAD C., Mechanical Engineer and Designer,
The Celluloid Co., Newark
JONES, PAUL, Works Engineer,
Bosch Magneto Co., Plainfield
PATTBERG, GEORGE, Assistant Service Engineer,
United Piece Dye Works, Lodi
ZISCH, GEORGE J., President and General Manager,
Newark Engineering & Refrigerating Co., Newark

New York

DAWLEY, HOWARD H., Safety Supervisor,
Remington Arms U.M.C. Co., Inc., Ilion
JOHNSON, ANDREW F., Designing Engineer,
E. L. Phillips & Co., New York
LAGERHOLM, AXEL F., Assistant Secretary,
J. E. Dockendorff & Co., Inc., New York
NEFF, WILLIAM L., Assistant to New York Manager,
Brown & Sharpe Mfg. Co., New York
PEARCE, CHOUTEAU E., Chief Engineer, Heating and Ventilating Department,
Richard D. Kimball Co., New York
ROSSMAN, JAMES G., Financial Manager,
William Hurd Hillyer, Investment Securities, New York
STEARNS, KARL T., Assistant Hydraulic Engineer,
St. Lawrence River Power Co., Massena

Ohio

BLUNDELL, EUSTACE E., General Superintendent,
The Cleveland Automatic Machine Co., Cleveland
CALLERY, J. General Manager,
The J. C. Callery Engineering Co., Columbus
KING, WILLIAM L., Construction Foreman,
General Electric Co., Cincinnati

Pennsylvania

FLYNN, JOHN H., Manager,
Blaw-Knox Co., Pittsburgh
HEINRITZ, WALTER J., Construction Engineer,
Counties Gas & Electric Co., Norristown
KANE, WILLIAM, President and General Engineer,
William Kane Mfg. Co., Inc., Philadelphia
KRONFELD, GUSTAVE L. S., Mechanical Engineer,
The Haynes Stellite Co., Pittsburgh
McNAUGHER, DAVID W., Partner,
Robert W. Hunt & Co., Pittsburgh
WILHELM, JOHN H., Superintendent of Gauge Department,
Frankford Arsenal, Philadelphia

Texas

HOGUE, WILLIAM H., Manager,
Magnus Co., Inc., Houston

Washington

CARPENTER, HUBERT V., Dean, College of Mechanic Arts and Engineering,
State College of Washington, Pullman

Wisconsin

BAILEY, ATWELL F., Assistant General Superintendent,
The American Appraisal Co., Milwaukee
BROWN, WALTER, Vice-President and General Manager,
The Webster Electric Co., Racine
OLSON, FRED S., General Superintendent,
The American Appraisal Co., Milwaukee
OLSON, LYLE H., General Manager,
The American Appraisal Co., Milwaukee
SMITH, CHARLES R., Appraisal Engineer,
The American Appraisal Co., Milwaukee

Chile, S. A.

HOFFMAN, ALBERT A., Construction Engineer,
Andes Copper Mining Co., Potrerillas

FOR CONSIDERATION AS ASSOCIATE OR ASSOCIATE-MEMBER

California

BEUTER, ARTHUR J., Technical and Sales Representative,
The Baldwin Locomotive Works, San Francisco

District of Columbia

JASPER, GROVER R., Purchasing Inspector,
Emergency Fleet Corp., Washington

Michigan

MERKER, PAUL O., Mechanical Engineer,
The Larrowe Milling Co., Detroit

New York

CASTONGUAY, ARTHUR F., with
Western Electric Co., New York

Ohio

BRIGHTMAN, HOWARD L., Works Manager,
Brightman Mfg. Co., South Columbus

Pennsylvania

STUCKEMAN, HERMAN S., Superintendent of Construction,
American Foundry & Construction Co., Pittsburgh

Cuba

LINTON, EARL B., Assistant Supervisor,
Cuba Can Corp., Pedroso Matanzas

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Colorado

KRUEGER, GEORGE H., Special Apprentice,
Great Western Sugar Co., Longmont

Connecticut

GORHAM, HOWARD W., Assistant Superintendent,
Raw Material Departments,
Bridgeport Brass Co., Bridgeport

PARKER, ARTHUR R., Engineer,
Remington Arms U.M.C. Co., Inc., Bridgeport
WILMOT, RUSSELL C., Engineer, Manufacturing Department,
The American Tube & Stamping Co., Bridgeport

Georgia

COWLES, CLIFFORD A., JR., Chief Engineer,
Atlantic Steel Co., Atlanta

Illinois

GULLEY, LAURENCE R., Manager and Chief Engineer,
The Burr Co., Champaign
NEWELL, JOHN C., Chief Engineer,
Keystone Steel & Wire Co., Peoria
RUSH, CLARENCE,
Automobile Construction Work, Chicago
SHUFF, EVANS L., Stoker Engineer, Service Department,
Westinghouse Elec. & Mfg. Co., Chicago

Indiana

CLANCY, WILLIAM C., Inspector Aeroplanes and Aeroplane Engines,
Signal Service at Large, Indianapolis

New Jersey

BOOZER, DOUGLAS G., Mechanical Engineer,
Eclipse Phonograph Co., Newark
BURNS, HERBERT A., Superintendent Material Department,
International Arms & Fuze Co., Bloomfield
KOERNER, THEODORE H., General Superintendent,
Newark Engineering & Refrigerating Co., Newark
KOHLER, ANTHONY M., Production Engineer,
The Babcock & Wilcox Co., Bayonne

New York

HAVENSTEIN, PERCY W., Engineer,
Viele, Blackwell & Buck, New York
HITE, HUGH D., Works Manager,
Intertype Corp., Brooklyn
ROTH, SAM L., Sales Engineer,
Pawling & Harnischfeger Co., New York

Ohio

BRIGHTMAN, HARRISON M., Superintendent,
The Brightman Mfg. Co., Columbus
BROWN, WARREN G., Works Engineer,
Modern Foundry Co., Cincinnati

Pennsylvania

GROFF, HOWARD M., Leading Draftsman, Gauge Division,
Frankford Arsenal, Philadelphia
McDERMET, JOHN R., Industrial Research Engineer,
Mellon Inst., University of Pittsburgh, Pittsburgh
SLAUGHTER, CHARLES H., Draftsman and Designer,
Jones & Laughlin Steel Co., Woodlawn

Wisconsin

JAHNKE, CHARLES B., Experimental Engineer, Mfg. Dept.,
Fairbanks, Morse & Co., Beloit
KLECKNER, A. C., Chief Engineer,
The Webster Electric Co., Racine

FOR CONSIDERATION AS JUNIOR

California

KNOX, GARNER L., Production Engineer,
Moreland Motor Truck Co., Los Angeles
WIGGERS, JOHN, Chief Engineer,
Moreland Motor Truck Co., Los Angeles

Connecticut

EDWARDS, GEORGE C., Foreman of Pull Socket and Assembling Department,
Harvey Hubbell, Inc., Bridgeport
SCHABECT, JOHN G., Tool Designer,
Remington Arms U.M.C. Co., Inc., Bridgeport

Georgia

BLECKLEY, LOGAN, JR., Experimental Engineer,
Atlantic Steel Co., Atlanta

Indiana

EDDY, BENJAMIN S., Heating and Contracting Engineer,
Indianapolis
HAMBROCK, OSCAR F., Special Apprentice, Office of Assistant Engineer of Motive Power,
Pennsylvania Lines, Ft. Wayne
ROBECHEK, BERT, Machinist,
Inland Steel Co., Indiana Harbor

Louisiana

SPRAGUE, FRANK E., Estimator and Designer,
John H. Murphy Iron Works, New Orleans

Maryland

LINCOLN, JOSEPH B., Mechanical Laboratorian,
U. S. Naval Engineering Experiment Station, Annapolis

Massachusetts

FERRETTI, ALFRED JOHN, Assistant,
Mechanical Engrg. Laboratories,
Massachusetts Institute of Tech., Cambridge

New Jersey

SUTTON, GRANVILLE G., Time-Keeper,
Brighton Mills, Passaic

New York

EVANS, LYNN B., New York Representative and Associate Engineer,
The Franklin Mfg. Co., New York
HEWARD, FRANCIS S. B., Manager, New York Office,
James Howden & Co., Ltd., New York
HOPKINS, PETER A., Engineer,
Penn Spring Works, Baldwinsville
KINGSBURY, CHESTER L., First Lieutenant Ordnance Dept., U. S. Reserve, and Assistant Superintendent of Shops,
Watervliet Arsenal, Watervliet
LYNE, LEWIS F., JR., President,
Oil Specialties & Supply Co., New York
SPRECKELS, CHARLES H., JR., Assistant Engineer,
New York Refinery of National Sugar Refining Co. of N. J.
Long Island City

Pennsylvania

ELLIOTT, GEORGE F., Engineer,
Elliott Co., Pittsburgh

Texas

AUSTIN, PAUL P., JR., Engineer of Tests,
Freeport Sulphur Co., Freeport

Vermont

HUBBARD, GUY, Assistant Purchasing Agent,
National Acme Co., Windsor

Canada

O'ROURKE, FRANCIS W., Tour Foreman and Chemist,
St. Maurice Paper Co., Ltd., Cap Madeleine, P. Q.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE

Connecticut

CASHEN, HENRY C., Master Mechanic,
The Bradley & Hubbard Mfg. Co., Meriden

PROMOTION FROM ASSOCIATE-MEMBER

CAMPBELL, JAMES A., Mechanical Superintendent,
Renfrew Mfg. Co., Adams

New Jersey

GATES, GRANDON D., Assistant Works Superintendent,
The Celluloid Co., Newark

PROMOTION FROM JUNIOR

Michigan

GRIMES, GEORGE L., President and Manager,
Midland Machine Co., Detroit

New York

BERRIAN, HENRY C.,
Engineering Dept., Federal Shipbuilding Co., New York
CONNETT, LYNDON R.,
L. R. Connett & Co., New York
JOHNSON, DAVID C., Engineer,
Kean, Taylor & Co., Bankers, New York
JONES, FORREST S., Chief Engineer,
Chas. Pfizer & Co., Inc., New York

Pennsylvania

JACOBSON, FRANZ, Checker,
Pressed Steel Car Co., McKees Rocks
MURPHY, EDWARD T., Vice-President,
Carrier Engineering Corp., Philadelphia

Texas

EDGAR, OSMER N., Engineer-in-charge, Industrial Department,
Houston Chamber of Commerce, Houston
HOSMER, FRED E., Mechanical Engineer,
Gulf Pipe Line Co., Houston

Canada

BILLINGS, J. H., Lecturer in charge of Machine Design Department, University of Toronto, Toronto

Hawaii

RENTON, JAMES L., Chief Engineer,
Ewa Plantation Co., Ewa

Total number of new applications..... 114

NECROLOGY

ALFRED J. ORMSTON

Alfred J. Ormston, Jr., was born in Oil City, Pa., on July 6, 1883. He received his early education in the parochial and public schools and the private school of Dr. Samuel Earp, of Oil City.

For several years thereafter he was employed in the office of Alfred Smedley, chief engineer of the National Transit Co., in Oil City, in the capacity of clerk and stenographer, resigning to engage in business for himself in the production of oil.

He later entered Carnegie Institute of Technology, Pittsburgh, from which he was graduated in 1912, having completed the course in mechanical engineering. The following year he taught in the Institute, and later went to Watertown, N. Y., where he was employed by the Massey Machine Co. in the capacity of mechanical engineer. While with this firm he invented and took out letters patent on a small governor for engines. He assigned this patent to the Massey Machine Co., who now manufacture it as their "Type O."

From Watertown Mr. Ormston moved to Woodlawn, Pa., where he was employed by the Jones & Laughlin Steel Co. For a time he occupied the position of assistant master mechanic, and at the time of his death was assistant to Mr. C. L. Dudley, steam engineer.

On the afternoon of July 31 he was scalded by the discharge from a steam siphon at the works and died the following morning. Mr. Ormston became a junior member of the Society in 1913.

EDWIN D. TUCKER

Edwin D. Tucker was born in New York City on October 10, 1865. He was educated in the public schools of the city and in Wilson and Kellogg's private school.

Upon leaving school he served his apprenticeship with the firm of R. Hoe & Co., and later obtained his drawing-room and shop experience with the same firm. He was later promoted to the position of foreman, holding this until 1906.

In the same year Mr. Tucker became associated with Sheppard Knapp & Co. and was treasurer of the firm for five years, when he retired from active business.

He became a member of the Society in 1898. He was also a member of the General Society of Mechanics and Tradesmen, and of The Franklin Institute of Philadelphia. He died on July 9, 1917.

MYRON KNOX RODGERS

Myron K. Rodgers was born in November 1861. He was graduated from Washington and Jefferson College in 1886, taking the first prize in chemistry.

He left immediatey for the West, obtaining a position as rodman on the Montana Central Railroad, then building into Butte. He was rapidly promoted until he was made resident engineer, having charge of several tunnels. When this road was completed he obtained a position as surveyor with the Anaconda Copper Mining Co., and was advanced in a short while to the position of chief engineer, which he held until 1896.

At that time he became associated with Mr. Marcus Daly of New York, who was very much interested in mining. Mr. Rodgers became Mr. Daly's mining expert and traveled all over the world examining mining properties for him. In 1907 he went into the mining business for himself. He opened up the Nickel Plate Mine at Hedley, B. C., and also the Hidden Creek Mine of the Granby Co., taking both of these properties as mere prospects and developing them until they were ready for the reduction works. He designed and built the Hedley Gold Mining Company's mill. In 1912 he became interested in mining property in Mexico, but the revolution stopped any mining operations in that country.

He became a member of the Society in 1894. He died in June 1917.

SYDNEY FRANCIS SAVAGE

Sydney F. Savage was born in 1889 in Cambridge, Mass., and received his early education in that city. He was later graduated from Lowell Institute.

He was employed in an engineering capacity with manufacturing concerns in the vicinity of Boston, including the Blake-Knowles Steam Pump Works and the Hood Rubber Co., until 1914, when he entered the employ of the United Illuminating Co., New Haven, Conn., in the engineering department.

Upon the formation of the firm of Westcott & Mapes, New Haven, he joined the organization as mechanical engineer, later becoming director and assistant secretary and successfully directing many important undertakings.

He became a junior member of the Society in 1914. He died on August 18, 1917.

DWIGHT BOYCE PANGBURN

Dwight B. Pangburn was born in Washington, D. C., on Nov. 27, 1889. Later the family moved to New Haven, Conn., where he was educated in the public schools, being graduated from the high school in 1907. The same year he entered Yale University in the Sheffield Scientific School. He took the regular course in mechanical engineering, and was graduated in the class of 1910. He continued his studies in the same line until 1912, when he received the degree of mechanical engineer. He was then appointed an instructor in the mechanical engineering department in Sheffield and was holding that position at the time of his death.

Mr. Pangburn's shop experience was limited. However, during one summer vacation he acted as consulting engineer for the Hendee Manufacturing Company, and during the following college year he conducted some scientific tests of the Indian motorcycle for the company at Mason Laboratory, Sheffield.

He wrote many scientific articles for various publications, and also a number of short stories for popular magazines. He was a recognized authority on bird life and was a charter member of the New Haven Bird Club.

At the time of his death he was collaborating with Prof. Richard S. Kirby in writing a textbook on descriptive geometry.

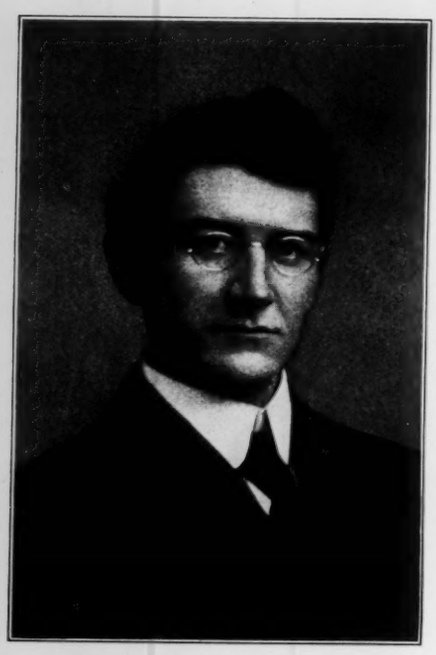
He became a junior member of the Society in 1912. He was also a member of the National Geographic Society. He died on Aug. 24, 1917.

EXECUTIVE COMMITTEE OF THE LOCAL SECTIONS OF THE A.S.M.E. 1916-17

C. R. RICHARDS

ELLIOTT H. WHITLOCK

D. ROBERT YARNALL
Chairman



WALTER RAUTENSTRAUCH

THE SECTIONS COMMITTEE HAS LAID OUT AN AMBITIOUS PROGRAM FOR THE SEASON. THE COMMITTEE WILL VISIT THE ST. LOUIS, MILWAUKEE, CHICAGO AND DETROIT SECTIONS THIS MONTH

L. C. MARBURG

AMONG THE SECTIONS

IN another part of the Society Affairs Section of this issue of THE JOURNAL is given a very comprehensive statement of what the Committee on Sections expects to accomplish during the season just commencing. Of direct interest to the readers of THE JOURNAL is the plan to have each Section present two papers for publishing in these columns.

The President has just completed plans for a Western trip, of which the following is the itinerary: Leave Worcester October 14; St. Louis, October 16; El Paso, October 18; Los Angeles, October 22; San Francisco, October 26; Seattle, October 28 or 29. The Sections at the Coast are looking forward with a great deal of anticipation to this visit, especially as Dr. Hollis will be accompanied by Mrs. Hollis.

The Executive Committees of all the Sections have been actively at work during the summer on their programs, and by the end of this month a few of the Sections will already be holding their initial meetings. In the November issue we hope to be able to publish the programs for the season of all the Society's twenty-two sections.

The Providence Engineering Society, affiliated with our Society, held its opening meeting on September 18. A representative of the A.S.M.E. was present who prepared an account of the meeting which is published elsewhere in this issue.

EXECUTIVE COMMITTEES OF THE SECTIONS

Atlanta

OSCAR ELSAS, *Chairman*; CECIL P. POOLE, *Secretary*; EARL F. SCOTT, ROBERT GREGG, J. N. G. NESBIT.

Baltimore

W. W. VARNEY, *Chairman*; L. B. ROBERTSON, A. G. CHRISTIE, C. C. THOMAS, W. M. CHATARD.

Birmingham

J. H. KLINCK, *Chairman*; W. P. CAINE, *Vice-Chairman*; J. G. HAYMAN, *Secy-Treas.*; PAUL WRIGHT, R. E. BRAKEMAN.

Boston

A. C. ASHTON, *Chairman*; W. G. STARKWEATHER, *Secretary*; RICHARD H. RICE, W. W. CROSBY, FRANK L. FAIRBANKS.

Buffalo

Committee to be appointed.

Chicago

ALEX. D. BAILEY, *Chairman*; H. T. BENTLEY, *Vice Chairman*; A. L. RICE, *Secretary*; P. N. ENGEL, G. R. BRANDON.

Cincinnati

Committee to be appointed.

Detroit

GEORGE W. RISSELL, *Chairman*; S. J. HOEXTER, *Secretary*; T. H. HINCHMAN, E. C. FISHER, RUSSELL HUFF.

Erie

Chairman to be appointed; M. W. SHERWOOD, *Vice Chairman*; R. CONRADER, *Treasurer*; M. E. SMITH, *Secretary*; N. A. NEWTON.

Indianapolis

W. H. INSLEY, *Chairman*; L. M. WAINWRIGHT, *Vice-Chairman*; B. G. MERING, *Treasurer*; F. C. WAGNER, L. W. WALLACE.

Los Angeles

F. G. PEASE, *Chairman*; T. J. ROYER, *Secretary*; RALPH SPRADO, H. L. DOOLITTLE, H. E. BRETT.

Milwaukee

W. M. WHITE, *Chairman*; FRED H. DORNER, *Secretary*; L. E. STROTHMAN, EDWARD HUTCHENS, M. A. BECK.

Minnesota

H. LEROY BRINK, *Chairman*; J. A. TEACH, *Vice-Chairman*; E. A. WILHELM, *Secy-Treas.*; J. V. MARTENS, C. W. TUBBY.

New Haven

H. B. SARGENT, *Chairman*; E. H. LOCKWOOD, *Secretary*; F. L. MACKINTOSH, J. A. NORCROSS, J. W. ROE.

New Orleans

H. L. HUTSON, *Chairman*; E. W. CARR, *Secretary*; W. B. GREGORY, A. M. LOCKETT, R. T. BURWELL.

New York

J. J. SWAN, E. J. PRINDLE, A. D. BLAKE, J. H. NORRIS, W. H. GREUL.

Ontario

R. W. ANGUS, *Chairman*; CHESTER B. HAMILTON, JR., *Secretary*; C. R. BURT, L. H. FLETEMEYER, G. V. AHARA.

Philadelphia

L. F. MOODY, *Chairman*; JOHN P. MUDD, *Secretary*; EMMETT B. CARTER, W. R. JONES, H. B. TAYLOR.

St. Louis

R. L. RADCLIFFE, *Chairman*; E. H. TENNEY, *Secretary*; E. FLAD, W. A. HOFFMAN, H. R. SETZ.

San Francisco

B. F. RABER, *Chairman*; A. C. PAULSMEIER, *Vice-Chairman*; C. H. DELANY, *Secretary*; ELY HUTCHINSON, OMAR DENNY.

Worcester

GEO. I. ROCKWOOD, *Chairman*; R. G. WILLIAMS, *Secretary*; V. E. EDWARDS, H. P. FAIRFIELD, F. W. PARKS.

Providence Engineering Society

ROBERT W. ADAMS, *President*; GEORGE A. CARPENTER, *First Vice-President*; WAYLAND T. ROBERTSON, *Second Vice-President*; JOHN T. FRANKENBERG, *Third Vice President*; WILLIAM A. KENNEDY, *Secretary*; and ALBERT E. THORNLEY, *Treasurer*.

Providence Engineering Society

The Providence Engineering Society can survey the work accomplished since its organization a year ago with just pride and satisfaction. The slogan of the organization, "Ideas + work = Results," has been productive of a very attractive group of meeting rooms, located on the top floor of the Rhode Island School of Design, conveniently located at 29 Waterman Street, Providence.

The first meeting of the season was held on Tuesday evening, September 18, at which Prof. J. Ansel Brooks, Past President of the P. E. S., gave an illustrated talk on My Trip to Honolulu. Professor Brooks spent about six months in the Hawaiian Islands last winter and spring, and secured a wonderful collection of photographs of the features of the Islands. Mr. John R. Freeman, Past President of the A.S.M.E., who visited the Hawaiian Islands en route to the Orient, was present and gave an interesting supplement to Professor Brooks's address.

The organization of the Providence Engineering Society embraces the following ten sections: Chemical, Dr. R. L. Lyons, Chairman; Designers and Draftsmen, Benjamin F. Waterman, Chairman; Efficiency, Howard D. Wilsox, Chairman; Fire Insurance Engineers, Paul A. Colwell, Chairman; Industrial Education, Professor William H. Kenerson, Chairman; Machine Shop, Arthur H. Annan, Chairman; Municipal Engineering, Karl R. Kennison, Chairman; Power, Warren B. Lewis, Chairman; Structural, Eugene B. Whipple, Chairman; and Student, George R. Sturtevant.

EMPLOYMENT BULLETIN

THE SECRETARY considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, by putting them in touch with special opportunities for which their training and experience qualify them, and for helping anyone desiring engineering services. The Society acts only as a clearing house in these matters.

GOVERNMENT REQUESTS

The Society has been asked to make suggestions of men for the following positions with the Government. Further information will be given on request. Non-members of the Society having the qualifications may avail themselves of these notices by enclosing with their reply a personal introduction to the Society.

INSPECTORS OF STEEL HELMETS (under Civil Service Commission):

(A) Steel welding and rolling. Two or three men will be needed. The inspection of processes covers the operation of rolling into sheets and the incidental welding.

(B) Pressing. Six men are needed. This is the ordinary operation of pressed metal work.

(C) Assembling. Four to six men are needed. These men will inspect assembling, including the addition of incidental hardware and the lining, and will be responsible for the finished articles.

(D) In addition, at least six men will be needed to inspect the helmet linings, which are made of felt and leather, sewed by machine. Men of shoe experience to be utilized here. 2174.

RATE SETTER IN ARTILLERY AMMUNITION DEPARTMENT with at least one or two years' experience or more at assembly work, or a man clever with his hands in order that he may jump in and do each operation himself with dispatch, and tabulate his results in a neat manner, thus giving an indication of how many pieces an hour can be done in the various operations of assembling artillery ammunition. The man should not be influenced either by workers or by foremen, and will report results directly to the officer in charge. The work covers a wide range—from small primer work to handling of 6.2 shells. Such a man would be paid at the rate of $0.50 per hour. 2182.

INSPECTORS OF ORDNANCE EQUIPMENT (under Civil Service Commission). Inspectors for hardware and metal equipment, comprising such articles as buckets, rings, fasteners, hand axes, wire cutters, intrenching tools, canteens, cups, meat cans, cutlery and other small articles of brass, iron, steel or aluminum. Men who have had a high-school or equivalent education and in addition have had four years' experience in a manufacturing plant making such articles as those described above will qualify for one class of inspectors. Another class are graduates from a college or university of recognized standing and who have had one year's experience in a manufacturing plant, on the practical end of the work. These men should be over 25 years of age. Duties will consist in the organization and supervision of the inspection work in plants where equipment as described above is being manufactured. Inspectors will also be responsible for the preparation of the necessary reports covering the inspection, shipment and payment for the articles described. 2195.

MECHANICAL DRAFTSMEN who have been called by the selective draft, may, if they desire, serve their country in their chosen profession by being transferred from their respective cantonments into the drafting force of the Ordnance Department as non-commissioned officers. For further particulars, address Gun Division, Ordnance Department 1330 F Street, Washington, D. C. 2223.

MECHANICAL DRAFTSMEN WANTED IMMEDIATELY by the Gun Division, Ordnance Department, Washington, D. C. For further information, communicate at once with the Gun Division, Office of the Chief of Ordnance, 1330 F Street, Washington, D. C. 2224.

For the following positions, Nos. 2171, 2187 and 2217, letters showing qualifications should be sent to the Secretary. Further information cannot be given at this time.

MECHANICAL DRAFTSMEN AND MECHANICAL ENGINEERS. Former to serve as civilians at salaries of from $1400 to $1800 per year. Latter to be commissioned as First or Second Lieutenant at from $1800 to $2000 per year. 2171.

INSPECTORS OF INSTRUMENTS, division of Signal Corps. Men not subject to draft and with technical training preferred, especially in physics. Not necessary to have thorough knowledge of aeronautical instruments. Manufacturing experience of value. Salaries from $1200 to $2200 per year. 2187.

TECHNICAL GRADUATES OF ESTABLISHED UNIVERSITIES WITH DEGREE OF M.E.

(A) Some technical and executive experience in operating industrial plants, for commissioned service with salaries ranging from $2500 to $3000.

(B) Men of principally technical and some special experience in designing and coördinating work for the manufacture of products similar to military and naval ordnance, aeronautical supplies, internal-combustion engines, for commissioned service with salaries ranging from $2500 to $3000. 2217.

POSITIONS AVAILABLE

In forwarding applications, stamps should be enclosed for transmittal to advertisers; applications for non-members should be accompanied by a letter of reference or introduction from a member, such reference letter to be filed with the Society. Copy for notices must be in hand by the 15th of the month.

INDUSTRIAL ENGINEER—COST ACCOUNTANT. A well-established firm can offer exceptional opportunities for effective and interesting work to engineering graduates who have had substantial experience with modern industrial accounting, with special preference to manufacturing costs. In reply state age, education, experience, present and expected salary. 431.

ASSISTANT DESIGNER AND WORKS MANAGER. High-grade company with factory located in western Maryland desires services of a man having a technical training in the foregoing capacity. Duties: To assist in designing special machinery and developing ideas; analyze machine operations, prescribe equipment and devise means to effect speedy and economical production; superintend the manufacturing of such machinery. Requires the ability of a thoroughly practical master mechanic with original ideas as to methods, a knowledge of modern shop practice, familiarity with the design and application of time-saving fixtures, executive ability and diplomacy necessary to successfully direct a manufacturing plant. No question of salary if the right man applies. State full particulars and experience from technical degree, with the assurance that such information will be held as confidential and no investigation will be made with present employer prior to conference. 958.

SUPERINTENDENT AND FOREMAN OF POWER PLANT. Man capable of taking complete charge of large smelter plant consisting of steam turbines, large blowing engines, large rotary blowers, Diesel engines, waste-heat and oil-fired boilers, pumping plant, high- and low-tension electrical equipment, etc. Must be familiar with combustion and operating problems and have organizing and executive ability. Salary about $2,500. Location Arizona. 1025.

RESEARCH—TESTS ENGINEER. Man with mechanical and electrical training, from 28-35 years of age, preferably over draft age, for work in the standardization of household equipment. Location New York. 1082.

MACHINE DESIGNER between 25 and 35 years of age, with mechanical and electrical engineering knowledge and sufficient shop experience to enable him to design apparatus so that it can be economically manufactured. Some pneumatic engineering experience preferred, but not absolutely necessary. Work: Improvement of present product in regard to increasing the quality of finished article. Design of new products now in process of development. Salary, $1,200 to $3,600, depending entirely on man. Location Hoboken, N. J. 1155.

SHOP SUPERINTENDENT for machine shop manufacturing planers, lathes, etc., and employing 200 to 300 people. Confidential. 1158.

COMPETENT MAN to take hold of maintenance and machine repairs and general shop economies. Prefer one about 35 years old.

with technical education and enough shop experience to understand the operation of all machine tools, and with a full appreciation of the value of time on an operation without going into any efficiency work. Opportunity for advancement and eventually an executive position. Location Ohio. 1166.

SALESMAN for mechanical apparatus. Salary depends upon the man. Location New York State. 1167.

EXPERIENCED SALES-ENGINEER FOR FRANCE desired by export house. Man who has actually sold machinery in that country. Must be competent to develop efficient sales organization, appoint subagents, etc. A substantial profit share will be paid in addition to salary, therefore exceptional opportunity. Address applications in French or English. 1173.

MECHANICAL ENGINEER familiar with general machinery in wood-working and machine shop to take charge of drafting room. At present planning ship ways, and the work for this particular engineer will be the laying out of the wood-working and machine shop, as well as derricks, cranes, etc. Location Pennsylvania. 1175.

PRODUCTION MANAGER. Man 31 to 40 years of age, with machine shop experience and familiar with modern production methods, for a permanent position in charge of planning production department of a large manufacturing concern. In first letter state qualifications fully and initial salary expected. Location New York State. 1176.

INSPECTOR. Energetic, capable young man as inspector in plant manufacturing small machinery and machine parts. Should have had experience as a machinist. State initial salary expected, age, experience and qualifications. Good opportunity for advancement. Location New Jersey. 1183.

STEAM ENGINEER familiar with operation of boiler work, combustion problems, etc., for New York concern. Salary $150. 1184.

SALES ENGINEERS. Men at least 34 years of age, with college education or its equivalent, who have had mechanical training and shop experience, in the sales department of a prominent manufacturer of pneumatic machinery. Good opportunity for the right men. Give references, experience and salary expected. Location New York State. 1187.

DRAFTSMAN with sufficient experience to enable him to take charge of the making and checking of detail drawings in a drawing room employing two or three men. State qualifications and past experience fully. Large part of the work will consist of routine calculations; applicants must be possessed of technical training. Salary about $150 per month. Location New York State. 1189.

FACTORY EXECUTIVE technically trained, about 30-35 years of age, for large textile-machinery manufacturing plant. Knowledge of up-to-date shop methods essential, also successful experience in the handling of mechanics. Applicant would be required to spend from one to two years in shop to become familiar with the various classes of work, after which the position of assistant superintendent with further excellent opportunities for promotion will be open to him. Salary to start, about $2,500. Location Massachusetts. 1191.

CHIEF DRAFTSMAN with executive and engineering ability, competent to direct the work of eight draftsmen and superintend design of output of plant manufacturing large tankage, steel-mill buildings, zinc-smelter equipment and cement-mill work, along engineering lines. Must be competent to operate system now installed in relation to billing, routing and ordering materials. Want man with at least ten years' experience in manufacturing lines. Salary $2,000. Location Kansas. 2013.

HIGH-GRADE TOOL DESIGNER with good experience on heavy automatic-screw-machine tools including Acme, Gridley, Brown & Sharpe and Cleveland automatics, and also capable of handling the problem of standardizing tools and tool records. Salary $25 to $30 per week. Location Ohio. 2037.

TWO TECHNICAL GRADUATES approximately 30 to 38 years of age with experience of sufficient breadth so that they would be posted on problems of manufacture in more than one line. Men who have been steadied by experience, yet ambitious to push ahead and interested in the various problems of manufacture and construction. Location Massachusetts. 2071.

DRAFTSMEN for Watertown plant. Salary $20 weekly. Apply by letter to Employment Dept., Maxim Munitions Corporation. Derby, Conn. 2124.

INSTRUCTOR with technical and actual operating experience to take charge of stationary engineering department where exceptional opportunity along educational lines is offered. Location Pennsylvania. 2126.

CONSULTING ENGINEER in connection with sale and installation of swivel joints. Position would require man to travel quite extensively to call and confer with the master-mechanic or engineer and see that our joints are properly installed. Position would be a dignified one and could be made very important, depending upon the results of the efforts put forth. Salary $50 per week and expenses. Location Wisconsin. 2133.

STRUCTURAL DRAFTSMEN. (A) For Government work, two timber draftsmen, probably men familiar with trusses and trestles, and one general draftsman for general tracing and drafting. (B) Six structural-steel designing draftsmen and three or four draftsmen familiar with foundation work. Location Maryland. 2136.

METALLURGIST. Large manufacturer of automobile parts operating steel mill and tube mill desires services of a thoroughly competent metallurgist. An exceptionally good opportunity to secure position with firm having a nation-wide reputation for producing a high-quality product. Location Middle West. 2137.

SALESMAN. Young man of some experience to sell or promote patent rights on commission. Only part time will be needed. 2138.

ENGINEER with thorough technical training and not less than five years' experience, capable of designing installations of machinery, tanks, etc., estimating costs and supervising erection. Work in connection with new centrifugal processes. Position permanent. Location Eastern Pennsylvania. 2142.

INSTRUCTORS in mechanical engineering for university in Middle West. Salary $1,300. 2143.

TOOLMAKERS AND TOOL DESIGNERS experienced on jigs, fixtures and gages. Only first-class men need apply. Good salary and best of working conditions. Location Pennsylvania. 2155.

MECHANICAL ENGINEERS. Rapidly growing company has openings for trained and experienced technical men, also for younger men with technical training in mechanical engineering. Apply by letter giving training, experience, and class of work desired, whether operating, efficiency work, or designing. Location Pennsylvania. 2156.

DRAFTSMAN experienced in marine-engine, water-tube boiler and river-steamer work. State age, salary expected and references. Location Charleston, W. Va. 2157.

SUPERINTENDENT for electro-chemical plant. Man with experience and executive ability, capable of handling about 50 employees. Salary entirely dependent upon man. Location Pacific Coast. 2159.

SUPERINTENDENT with not less than five years' experience in factory management, to take charge of a factory employing 600 to 700 people; a man who is leader of men; who has had training as a mechanical engineer and if possible a designer of automatic machinery. Good opening for right kind of high-grade man. Confidential. 2160.

DRAFTSMEN experienced in power-plant work. College graduates preferred. Salary $125-$180, according to individual. Location New York. 2161.

DESIGNER of power-plant work. College graduate preferred. Salary $125-$180, according to man. Location New York. 2162.

MECHANICAL ENGINEER with originality and experience in supervising all details of engineering department. Must be capable and resourceful practical designer. Work of an industrial nature, covering smelting practice and coal- and ore-handling equipment. Large plant located in Eastern Pennsylvania. Salary $250 per month. Apply by letter. 2163.

YOUNG MAN not over 35 and not subject to military draft. Must possess some technical training or experience in mechanical lines, including drafting, be energetic and have executive ability. Salary to start, $1,300 to $1,500. Location New York State. 2166.

PRODUCTION MANAGER with experience in the manufacture of machine tools and specialty appliances. Location New England. Salary depends entirely upon individual. 2170.

SALES ENGINEER. Man competent in handling and selling reinforcing, bar steel, pig iron, coke, etc. Position requires man with some technical knowledge, preferably one with an engineering training and some practical experience in steel construction. Energetic and aggressive salesman of good character desired; one who will be loyal, and while anxious to advance, will not be disposed to fly from job to job. Salary about $4000. Location Pacific Coast. 2172.

DRAFTSMAN, preferably one with some experience in general machine design and steel-plate work. Salary $75 to $90 per month. Good opportunity for advancement. Location Pennsylvania. 2173.

EXPERT IN CHECKING UP DRAWINGS to work on special machinery, coke ovens, etc. Salary up to $175 per month, depending upon individual. Location New York. 2175.

DESIGNERS. First-class men experienced on tools, fixtures and gages. State full experience. Location Illinois. 2176.

DESIGNER of regulators and a designer of tools. None but thoroughly experienced man need apply. Good opening with big manufacturing company. Location Middle West. 2177.

PHYSICISTS, CHEMISTS, ENGINEERS, DESIGNERS AND DRAFTSMEN for work of research, development, and design related to problems of telephonic, telegraphic and radio communication, which are matters of public importance. Opportunities for such men in both temporary and permanent positions. Apply by letter. Location New York. 2178.

ENGINEERS FOR STEEL PLANT. Four positions open in modern plant. Mechanical and civil engineering experience desirable. Salaries $125, $150, $175. Location Pennsylvania. 2183A.

MECHANICAL ENGINEER with some knowledge in installing and operating mining and ore-dressing machinery. Must be capable of starting and planning mining enterprises, and must study Russian if he does not already know it, and bring with him certain American agencies in the lines of mining machinery. Location Russia. 2183B.

PROFESSOR OF MACHINE DESIGN in mechanical engineering department of university in Middle West, to teach the subjects usually included under this title, with possibly some laboratory work on the strength and other physical properties of materials. Salary about $2500. 2184(1).

INSTRUCTOR IN MECHANICAL ENGINEERING, at $1400 to $1500, to teach a few hours of class-room work in elementary steam engineering and some elementary laboratory work, including gas-power laboratory. Prefer a man who desires to specialize in gas-power laboratory work. 2184(2).

TWO ASSISTANTS IN MECHANICAL ENGINEERING, at $850 for 9 months' work. One to have charge of the instrument room and the other to be assistant in office; both to do some correction of laboratory reports and class exercises. 2184(3).

SUPERINTENDENT OF AERONAUTICAL LABORATORY and its six or eight instructors in our School of Military Aeronautics. Should be a man of mechanical-engineering training who has specialized and has had considerable experience in the operation and testing of aeronautical engines, a good teacher, with executive ability in supervising and directing the work of the laboratory of 250 to 300 students. Such a man would receive at least $200 per month, 12 months in the year, indefinitely. 2184(4).

UNDERSTUDY to the superintendent of aeronautical laboratory called for in Position No. 2184(4). Would expect to pay from $150 to $175 per month. 2184(5).

DESIGNING DRAFTSMAN, man experienced on water-tube marine and stationary boilers and superheaters only need apply. Good position for competent man. State education and experience in detail, age and salary expected. Location New York. 2185.

YOUNG MEN wanted by manufacturers of mechanical instruments for indicating and reporting pressures, temperature, speed, etc. The position is ultimately that of traveling salesman with attractive pecuniary inducement. The start will be modest, as a course of training must be gone through at home office in New York. 2188.

INSTRUCTOR IN MECHANICAL DRAWING AND MACHINE DESIGN in the extension division of a university in the Middle West. Position consists in taking care of all correspondence study work in the above subjects and also in the revision and preparation of courses along this same line. Salary from $1500 to $1800 per year of 11 months. 2189.

YOUNG ENGINEERS with good technical education and from one to three years' experience along general mechanical-engineering lines. Must be of good personality, energetic, persevering and capable of considerable development; good opportunity for advancement. Address E. I. du Pont de Nemours & Co., Engineering Department, Wilmington, Del. 2192.

DESIGNER AND ASSISTANT OFFICE EXECUTIVE of power plant. Salary $150 to $175 per month. Location New York State. 2194.

AGENT FOR STEAM-BOILER AND FLYWHEEL INSURANCE. Applications will be treated confidentially from men who have demonstrated their ability to produce business in these lines. State fully experience and compensation desired. 2196.

YOUNG SALESMAN for New York City. Applicant should preferably have had experience in connection with building operations and must be a man of good address and pleasing personality. 2197.

TWO TECHNICAL MEN, one to act as a service engineer, the other as a sales engineer. The former need not necessarily be a technical graduate, but should be familiar with die design and hydraulic-press work. For the latter position desire a technical graduate familiar with automobile starting, lighting and ignition apparatus and electrical devices in general. Experience in plastic molding or die design would be advantageous. If applicants are between the ages of 21 and 31 they should show cause for exemption or have numbers near the end of the draft call. Prefer single men, since the positions will require considerable traveling over a wide territory. Product is highly specialized and the first two or three months of employment will be spent in the shop and laboratory. Salary commensurate with experience and ability. 2198.

DETAILER on interchangeable-parts machinery. Salary $25 to $35, depending upon individual. Location New York State. 2199.

CHIEF DRAFTSMAN, experienced on tools, jigs and fixture design, to take charge of a dozen men. Prefer man from 25 to 35 years of age with shop experience in the manufacture of interchangeable parts and with executive ability so that he can assist the superintendent directing the technical work. Salary $200 per month to start. 2200.

ASSISTING MANAGER for large chemical plant. Location New York State. 2203.

OFFICE EXECUTIVE to take charge of correspondence, routing of salesmen, agencies, etc., in connection with an industrial electric-truck manufacturing plant. State experience. Salary to start $2400. Appointment by letter. Location New York State. 2205.

YOUNG MECHANICAL ENGINEER, preferably a recent college graduate, to work up in engineering and steel export department, with probability of eventually taking charge. Location New York State. 2206.

DETAILER on hoisting and conveying. 2208.

YOUNG TECHNICAL GRADUATE as instructor in machine design in the mechanical engineering department of eastern college. Salary $1200. Work begins September 20. 2209.

TOOL DESIGNERS. First-class men for permanent positions. Location New Jersey. 2210.

DRAFTSMEN for power station of railway. Salary $100 to $150 a month. Location Ohio. 2211.

CONSTRUCTION SUPERINTENDENT on brick, iron and combustion. Single man preferred. Salary $175 to $200 a month. Location New York State. 2212.

EXPERIENCED DRAFTSMAN on jigs and fixtures. Good pay and opportunities. Location New York State. 2213.

INSTRUCTOR, with the rank of assistant professor, in engineering mechanics, strength of materials, materials testing laboratory, and hydraulics, for the University of Oklahoma, at Norman, Okla. Salary $1400 for year, with annual increase of $100. The position is for the duration of the war, possibly longer, as the school is growing rapidly. The man will have full charge of the work and be free to use his own methods and text. A teacher of considerable experience in these subjects might be paid more than the above salary. Recent graduates, preferably with some teaching experience, who intend to follow teaching as a profession, will be given careful consideration.

A similar position at the same pay and rank is open in the steam engineering and mechanical laboratory. This position is permanent. 2214.

MAN to assist in the design of laboratory of university in New England, later instructor in night course, to equip motor-vehicle laboratory for the experimental study of the factors entering into the construction and design of motor vehicles, including engine and chassis. 2215.

DETAILERS. Young engineers for work on specifications. Location New York State. 2216.

SUPERINTENDENT, preferably under 50, with enthusiasm and thoroughly conversant with shop routing, cost accounting, and ability for organizing. Position is available at once. Salary between $4000 and $5000 per year. Confidential. 2218.

DETAIL DRAFTSMAN, experienced on jig, fixture and tool designing. Salary $25-$28 per week. Also a man capable of taking charge of

the drafting room at salary depending upon applicant's qualifications. Location Connecticut. 2219.

FACTORY SUPERINTENDENT. Man thoroughly experienced in machine-shop practice and modern centralized planning-control methods; capable of securing large production in the most efficient, economical manner. Factory is divided into divisions of brass and iron foundry, structural steel, machine shop, pattern-making, wood work, polishing and plating. Product is light, generally concerned in the production of cash carriers, pneumatic-transmission tubes and light-duty conveying machinery. Location Massachusetts. 2220.

MECHANICAL DRAFTSMEN having such experience in heating and general plant work as would regularly occur in the office practice of the average consulting heating engineer. Location Baltimore. 2221.

INSTRUCTOR IN MECHANICAL ENGINEERING to teach mechanical drawing and descriptive geometry in an engineering college on the Pacific Coast. Salary $1200 to $1400. 2222.

ASSISTANT OR ASSOCIATE PROFESSOR OF MECHANICAL ENGINEERING in charge of department, with salary of $1800 to $2000 for ten months, depending upon qualifications. These should include graduation from a technical school and both teaching and practical experience. Candidates should send without delay late photograph, full record of experience, and credentials. Location Idaho. 2225.

ELECTRICAL ENGINEER, with two or three years' experience developing automatic motor control for heavy machinery. Location near New York. 2226.

YOUNG MECHANICAL OR ELECTRICAL ENGINEER as assistant to executive in New York engineering office. Duties will be largely secretarial. Technical education and combined engineering and business experience are desirable. Salary $2000 to $2500. Apply by letter. 2228.

CHIEF DRAFTSMAN. Permanent position for chief mechanical draftsman with large firm manufacturing a number of heavy standard lines, boilers, engines, sawmill and pulpmill machinery, municipal machinery, etc. Location in city in Central Ontario, Canada. Apply by letter. 2229.

ADVERTISING MANAGER for large industrial corporation in New York City. Familiarity with advertising writing, printing, publishing, etc. 2230.

MEN AVAILABLE

Only members of the Society are listed in the published notices in this section. Copy for notices should be in hand by the 15th of the month, and the form of the notice should be such that the initial words indicate the classification. Notices are not repeated in consecutive issues.

EXECUTIVE position in the steel business—either in the manufacturing or sales end—desired by an American, technical graduate. Age 36, married. Fifteen years' experience in steel plant, general construction and varied engineering work. At present employed. Will arrange for New York interview. J-320.

CHIEF ENGINEER OR MASTER MECHANIC, now employed. Thorough technical and practical experience, covering the construction, operation and upkeep of steam and hydraulic power plants in connection with industrial works. Specialty: steam and fuel economy. Salary $2500. Available about October 1. J-321.

JUNIOR MEMBER, age 34, with 16 years' general engineering and operating experience, wishes position as malleable foundry engineer or superintendent in connection with engineering concern doing foundry work. Specialized in foundry equipment design, pattern making and mounting for multiple production, furnace operator, core making for agricultural-implement works and malleable pipe fittings. J-322.

SUPERINTENDENT OF POWER of steam-electric and compressor plant, age 31, married, technical graduate. Seven years' experience in design, construction and operation of steam-power plants and electric-transmission lines. At present superintendent of 10,000-hp. power plant for mining company in the Southwest. J-323.

MAINTENANCE ENGINEER OR SUPERINTENDENT OF POWER. Resigned from position as power and maintenance engineer of large industrial plant, and now available for position along similar lines. Have good general education, supplemented by special engineering and business courses of study. Four years of special machine-shop instruction; four years field erection and construction work on large engine, steam-turbine generators, refrigerating and structural machinery. Ten years with large western industrial plant as chief engineer of power plant and power and maintenance engineer. Have originality, training and experience to handle a big job where initiative and hard work will bring recognition and advancement. Non-user of tobacco and alcohol. Refer to former employers as to character and ability. J-324.

MECHANICAL ENGINEER. Technical graduate with experience in time-study, planning, production and inspection work, desires position of responsibility with manufacturing concern. J-325.

MECHANICAL ENGINEER—FACTORY EXECUTIVE. Graduate M.E. with 14 years' practical manufacturing experience. Has held positions as master mechanic, mechanical engineer and factory superintendent with large manufacturing company. Experienced in duplicate manufacture of light and medium-heavy machinery, also in woodworking from standing timber to highly finished cabinet wood. With present employers the past 11 years. Desires position with growing concern with opportunity to obtain financial interest. Middle West preferred. J-326.

MECHANICAL ENGINEER, 37 years old, with 18 years' practical experience with machine tools, steam turbines and engines, boilers and special machinery, exceptional theoretical knowledge, ability in design testing and operation, desires change. Also have had some sales experience. Location anywhere, but Middle West preferred. J-327.

MECHANICAL AND ELECTRICAL ENGINEER, age 34, married, technical graduate, 10 years' experience in power-plant design, appraisal and operation, also consulting and efficiency work in manufacturing. Can design, supervise or organize new work. At present employed, but desires new connections with ample opportunity to produce results. Salary, $3600. J-328.

EXECUTIVE OR WORKS MANAGER, age 34, married, technical, mechanical and electrical engineer with wide experience as executive manager and engineer; specialized in power-plant design and operation. Also experienced in industrial efficiency and appraisal work. Can furnish best of references. Salary $4000. J-329.

FACTORY EXECUTIVE. University graduate in mechanical engineering, 38 years old, wishes to make connections with modern concern manufacturing small mechanical or electrical apparatus in large quantities. Has thorough knowledge and practical experience in modern factory organization, manufacturing methods and employment matters. For several years connected as production manager and assistant factory manager with first-class concern employing 1800 men. J-330.

MECHANICAL ENGINEER OR SUPERINTENDENT. American, with 14 years' practical experience, also theoretical experience. Specialist in valves, fittings and engineering specialties of all descriptions; machines, tools, fixtures and equipment for same, shop maintenance; efficiency and production engineer. Successfully held positions and has references verifying above experience. J-331.

EXECUTIVE, ASSISTANT TO EXECUTIVE OR MECHANICAL ENGINEER. Cornell graduate, age 36, 12 years' experience in positions covering chief executive, office management and works manager, operation and construction and experimental work. Experienced in combustion, steam and gas power. At present employed. J-332.

SELLING ENGINEER, 27 years old, with 10 years' experience in power, gas and chemical equipment design and construction, desires position in sales work; has excellent business training; active worker with initiative and technical ability. J-333.

MECHANICAL ENGINEER OR CHIEF DRAFTSMAN. American, 41, with broad experience in meeting unusual conditions in collieries, smelters, chemical operations, etc. Can supervise work in shop or field. Salary $3000. New York district or foreign. J-334.

MASTER MECHANIC OR SUPERINTENDENT OF CONSTRUCTION. Technical education and 20 years' practical experience. J-335.

INSTRUCTOR in mechanical engineering, with five years' experience in drafting room, shop and laboratory, seeks extra work to be done in his office. Location New York City. J-336.

SALES ENGINEER, OFFICE EXECUTIVE OR DISTRICT MANAGER. Technical graduate, ten years' experience in eastern territory, highly successful in present work as a business getter, seeks larger field where energy and ability to show results are wanted. Nine years in present position. J-337.

PRACTICAL ENGINEER with broad tool-designing and machine-shop experience desires a responsible position where an agreeable personality, ability to handle men, an evening-school technical education, coupled with a capacity to "deliver the goods," will pave the way to a good future. For the past year and a half employed by a large ordnance firm to investigate their machine-shop methods and tools. Age 28, last numbers in draft. Salary $300 per month. J-338.

EXECUTIVE MANAGER. An executive of ability and aggressiveness, a mechanical, technical graduate, at present employed, desires to connect with a manufacturer whose business may need systematizing and building up as to organization and production. Has had a varied experience in different branches of manufacturing, operating industrial plants along lines of scientific management, and is fully conversant with modern methods of manufacturing and marketing product. Only

interested in a permanent position offering good possibilities for improvement. J-339.

MECHANICAL ENGINEER, 45, married; 10 years' shop experience and 14 years' experience in drafting, special machine design, surveying, mapping and construction work; good knowledge of elevating, conveying, screening and power-transmission machinery. Good organizer and executive and can handle men and get good results. Lately returned from resident engineer's position in foreign country on account of war conditions. Will go anywhere if conditions and salary are right. J-340.

CHIEF ENGINEER OF POWER PLANTS OR PLANTS AND SUPERINTENDENT OF GAS WORKS. Age 46, married, Assoc. Mem. Am. Soc. M. E. Eight years in present position. Holds Massachusetts first-class engineer license; has had extensive experience on both General Electric and Allis-Chalmers turbines and different types of water-gas machinery and almost all types of steam boilers at various pressures. Has good executive ability. Would consider a position in the east, Massachusetts preferred. Salary $3000. All correspondence will be treated confidentially. J-341.

TECHNICAL GRADUATE M. E., with two years' practical experience in general engineering. At present employed as assistant to factory engineer of an industrial plant. Has had considerable experience in designing and construction work. Position in the East preferred. J-342.

PURCHASING ENGINEER. At present engaged with large corporation and in touch with production and export organizations; qualified as a man of affairs and technically in machinery, metal products, machine tools, electrical equipment and engineering materials. Desires to change, assuming greater responsibilities and expecting commensurate salary. J-343.

DRAFTSMAN. Graduate mechanical engineer, age 24, with 18 months' experience in the design and layout of refrigerating plants and machinery, desires position, preferably in the East. Available on short notice. H-344.

COMBUSTION AND STEAM ENGINEER. Junior member, Cornell graduate, age 28, experienced in fuel and combustion engineering, testing boilers, engines and stokers and also cost distribution and operation, maintenance, construction and supervision of power-plant equipment supplying compressed air, steam, refrigeration and hot water and steam heat. Salary $2000. Location New York. J-345.

EMPLOYMENT MANAGER, at present employed in that capacity, wishes to make a change. Thoroughly competent to hire all classes of help, having had 18 years' practical mechanical experience. Age 37, married. J-346.

FACTORY EXECUTIVE, MASTER MECHANIC OR PLANT SUPERINTENDENT. Age 39, 18 years' experience as production superintendent in the manufacture of engines, condensers, high-vacuum air pumps, centrifugal pumps, etc. General engineering work, both medium and heavy. Has traveled extensively in connection with field work on same. Good executive of pleasing personality, alert and resourceful, exercising well-balanced judgment in all dealings and retaining confidence of organization. J-347.

MECHANICAL ENGINEER. Purdue graduate, age 29, married; experienced along lines of design, construction, installation, purchasing and management, with reference to buildings, machines and department layouts. At present employed as supervisor over large drafting room. Salary $200 to start. J-348.

EQUIPMENT ENGINEER, PRODUCTION MANAGER OR SUPERINTENDENT with thorough knowledge of manufacturing methods and processes and ability to apply them to get the maximum production from the equipment and men employed. J-349.

MECHANICAL ENGINEER OR ASSISTANT TO EXECUTIVE. Technical graduate, age 25, two years' experience in the manufacture of internal-combustion engines. At present employed. Salary $1800. Location New York City or vicinity. J-350.

ENGINEER OR CHIEF DRAFTSMAN. Technical graduate with 18 years' experience as designer, chief draftsman and assistant engineer, desires responsible position. Familiar with design of centrifugal and steam pumps, steam engines, elevating and conveying machinery, shoe machinery, ball-bearing manufacture; also machinery for making asphalt paper and shingles, power transmission, general factory equipment and maintenance. Salary $2500. Open for engagement Jan. 15. J-351.

CONSULTING OR ADVISORY ENGINEER. Member with large executive and manufacturing engineering experience on equipment, upkeep, design of tools, machines, ways and means and industrial economies in general, desires to serve a few reliable manufacturing concerns in a consulting, advisory or designing capacity. J-352.

RAILROAD EQUIPMENT EXPERT. Age 33, college education. Several years' varied experience in designing, construction, estimating, sales, shop, office, executive on various types of railroad equipment, including buildings and power plants, foreign and domestic. Speaks foreign languages. Best of references. J-353.

MECHANICAL ENGINEER, EXECUTIVE. Age 31, married. Technical education, with two years' commercial experience and six years as designer on steam turbines and power plant. Desires position as works engineer or assistant to executive in manufacturing or engineering firm. Excellent health and habits. J-354.

MECHANICAL ENGINEER. Associate member, age 30. Technical training; three years in civil engineering work, foundation, concrete, steel building and power-house erection; four years' mechanical-engineering experience on boilers, engines, special apparatus, hydraulic machinery, shop work, producer-gas engines and generators, industrial plant work; two years in electrical work on a.c. and d.c. generation, transmission and distribution. Good executive. Desires to specialize. J-355.

PLANT ENGINEER OR ASSISTANT TO EXECUTIVE. University graduate, mechanical engineer, not liable for military service under present conscription law. Fourteen years' varied experience in engineering work and design; familiar with modern shop methods and follow-up; thoroughly practical, with executive ability; not afraid of work or responsibility. Desires to communicate with only those who intend to employ a competent assistant for a number of years. J-356.

EXECUTIVE MECHANICAL ENGINEER. Cornell graduate, age 35, married, fourteen years' practical experience in machine tool use, manufacturing and commercial branches of business; trained in sales engineering and general management. Seeks responsible executive position as general manager or sales manager of progressive machinery manufacturer. J-357.

MECHANICAL ENGINEER with 15 years' experience in designing, estimating and general drafting in excavating machinery, hoisting engines, derricks and miscellaneous machinery, also some experience in machine shop and cast-steel foundry practice, desires a position as chief draftsman or assistant engineer with a concern where there is a good future. Now employed. Middle or Far West preferred. J-358.

ASSISTANT MECHANICAL ENGINEER, ASSISTANT MASTER MECHANIC, ASSISTANT TO MANAGER OR ASSISTANT TO EXPERIMENTAL ENGINEER. Member, born in Norway; age 42, technically educated, married; 21 years' designing and executive experience with large concerns. Has good sound judgment. Anticipates making a change and can go at a week's notice. Location New York or Brooklyn preferred. J-359.

INDUSTRIAL ENGINEER. Junior member, American, age 28, married. Six years' experience in all branches of manufacture of small parts with concern employing 3000 men in time-study work, planning, routing, estimating costs, etc. Experience in detail upon request. At present employed. Good executive ability proved. J-360.

MECHANICAL ENGINEER. Columbia graduate, 1912, with five years' experience in design, construction and inspection work with prominent concerns. Well grounded in machine design, plant layouts, and equipment. Desires position in engineering department, or as assistant to department head. Preference given to opening presenting chance to advance. J-361.

MECHANICAL ENGINEER. Columbia graduate, age 37, married. Fourteen years' service in motive-power department of large western railroad, in testing laboratory, as draftsman, assistant engineer of tests and assistant mechanical engineer. Desires opportunity for advancement and greater responsibility. At present employed. J-362.

TECHNICAL GRADUATE in mechanical engineering desires employment leading to a position in efficiency department. Experience has been mainly with mining machinery and jigs and fixtures. Has had experience in machine shop. J-363.

MECHANICAL ENGINEER. Stevens graduate, age 28, with five years' experience with Diesel engines and auxiliary machinery, desires position with more direct bearing upon the prosecution of the war than present position offers. J-364.

ASSISTANT TO EXECUTIVE. Young technically trained engineering draftsman, exempt from military service, desires a change. Experience covers general steel-mill engineering, construction and machine design. Location Chicago. J-365.

AERONAUTICAL MECHANICAL ENGINEER, age 28, three years' engine experience in aeronautics, also auto-engine experience. At present employed in Buffalo. Desires to enter the production field as production expert or inspector. J-366.

MANUFACTURING EXECUTIVE. Member, age 34, who is a technical graduate and has handled propositions in organization of gas, munitions and artificial silk properties, is now available. Salary $6000-$7200. Location immaterial. J-367.

ENGINEERING SURVEY

A Review of Engineering Progress and Attainment in Mechanical Engineering and Related Fields, Including a Digest of Current Technical Periodicals and a Selected List of Engineering Articles

British Workshops and the War

IN a speech delivered in the House of Commons, June 28, 1917, by Christopher Addison, then Minister of Munitions in the British Cabinet, it was stated that the program decided upon by the British Government in 1915, as regarded the production of munitions, required the erection of large additional factories in many lines. As a result of this policy, many products have been manufactured at a price considerably below that which prevailed in the market at the time of the erection of the factories. Thus the present cost of production of one of the basic high explosives, trinitrotoluol, at Queensferry, exclusive of interest and amortization, is 8½d. per lb. When the factory was started the cost in the market was 1s. 9d. per lb.

In connection with the manufacture of explosives and under an arrangement with the Food Production Department, a section of the Explosives Supply Department has been started for the provision of all the artificial fertilizers which are required. The control of the iron and steel industries gives all the basic slag that is wanted, and it is expected that the entire war problem in fertilizers will be met and give more than one million tons of superphosphates, nearly half a million tons of basic slag and a quarter million tons of sulphate of ammonia. Further, through the ingenuity of Mr. Kenneth Chance and his staff, a process has been discovered whereby great quantities of potash may be obtained sufficient to meet the requirements of the optical-glass trade and leave some surplus for the needs of agriculture.

The production of sulphuric acid has also been greatly increased. In particular, that of fuming acid is more than fifteen times greater than it was before the war and costs less to produce.

That the production of gun ammunition and fuses has been increased many times is a well-known fact. It is less well known that a new explosive component has been found and apparently thoroughly tested out.

Many of the filling and shell factories are worked by voluntary boards of management. At present the whole work of filling employs about 100,000 persons, and the cost of filling has been reduced by 40 per cent, as compared with what it was a year ago.

The inspection department has grown tremendously in the last two years, both because of the increasing magnitude of production and because of the greater diversity of the munitions supplied. In July, 1915, the staff of the inspection department consisted of 8761 persons. It now consists of nearly 40,000 persons in the United Kingdom, with an additional staff in the United States of more than 8000. An effort has been made to employ women in every possible way. In March, 1916, they composed 28 per cent of the staff. They now compose 61 per cent, numbering 29,000, and they are employed on almost all operations except those in which special technical experience or physical strength are required.

Notable improvements in design are claimed to have been made. During the Battle of the Somme reports were constantly received that a considerable number of rounds of ammunition either failed to explode or burst prematurely. This has been eliminated to a considerable extent.

As regards the development in gun supply, the demand for guns for anti-aircraft purposes and for the arming of merchant ships has placed a particularly heavy strain upon the country's capacity for producing long-range guns for use in the field. At the same time the output at Enfield has increased tenfold and the weekly capacity for the production of machine guns is more than twenty times greater than it was two years ago. Some months ago the output of small-arms ammunition became so abundant that it was found unnecessary to place any orders outside of the United Kingdom. The arsenal at Woolwich has increased tremendously. In August, 1914, the staff consisted of 10,866 persons. Now it amounts to 73,571. The number of women employed in 1914 was 125. Now it is close to 25,000.

A significant instance of how the war helped allied industries is cited in the case of glass for optical instruments. Before the war England would rely on home sources for only about 10 per cent of the glass used in optical instruments, being dependent mainly on German and Austrian supplies. Since the war, however, difficult formulæ have been worked out, especially by Professor Jackson and his colleagues, and under comprehensive arrangements England not only has adequate supplies for herself, but is able to provide substantial assistance to her allies. In fact, the whole group of industries connected with the glass trade has been placed on a secure foundation.

The great provider of the war industries, the machine-tool department, is the servant of all and has to furnish every variety of machine from the smallest tool, or lathe, to the mightiest crane. The department has a machine-tool clearing house by which idle and insufficiently used machinery is investigated and examined and an attempt made to divert it to better use. During the past seven months (previous to June, 1917), this branch investigated 22,027 applications and succeeded in releasing 42,638 machines roughly valued at more than £3,000,000.

The "tank" made its appearance last autumn. At the close of the year much work was still required to be done in the way of alterations and improvements, but the supplies of new designs are coming forward excellently. The end of the story is not reached and constant improvements are being made.

As regards aeroplanes, it had been found that the mobilization of all resources for the production of internal-combustion engines under a unified scheme of direction was essential. Such a working relation was established. Formerly there were a number of shops which were producing a number of different types of engines. By a continued effort to diminish the number of types and to concentrate on the best, with the policy of maintaining one shop devoted to the production of only a single type of engine, an enormous increase

in production has been obtained apart from the addition either of machinery or labor. The output of aeroplanes is rapidly increasing. The production for May is more than twice that of December and four times greater than that of May 1916. The supply, however, will become much greater still in a few months' time, for the government is working at a vast problem of production and the plans provide for its full realization.

The following statements are made as regards the effect of the submarine campaign on the production of munitions. In overseas supplies alone the Ministry of Munitions is interested in nearly 1,500,000 tons of munitions monthly. Of shell components shipped from North America to supplement home production the total loss since the commencement of the unrestricted submarine campaign, taking the heaviest item of

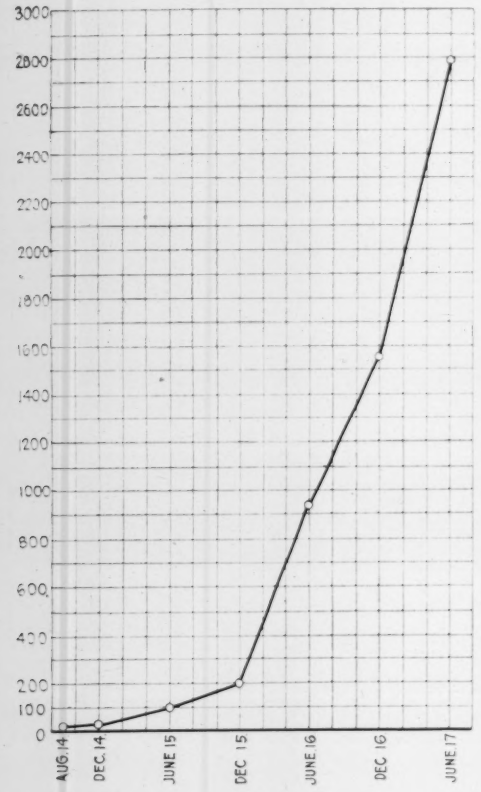


FIG. 1 INCREASE IN PRODUCTION OF BRITISH MUNITIONS, BY WEIGHT

loss in any single component, is only 5.9 per cent of the amount shipped.

As regards the American and Canadian supplies, it is stated that until recently all purchases were made through J. P. Morgan & Co. Lately, however, Mr. Gordon, the Vice-Chairman of the Imperial Munitions Board of Canada, at the request of the Minister of Munitions, has moved to the United States and has been appointed as the head of all British munitions organizations there and will report to Lord Northcliffe. Negotiations are now (June 1917) proceeding at the suggestion of the United States Government for a further consolidation of interests on both sides.

A vigorous attempt has been made to economize in the use of metals and a part of the program was the institution of scrap collection and distribution. For this purpose an extensive salvage department has been established, which works in coöperation with the armies at the front. The Minister of Munitions proposed to re-form hundreds of thousands of 18-pounder cartridge cases. When it is remembered that the price of a new case is about 7s., that it can be re-formed four times, and that the process of doing it costs 4d. a case, the importance of this branch is obvious. Another committee is charged with the duty of devising ways of economizing in the use of the more expensive metals. In this way a reduction in the amount of copper used in copper bands is secured, amounting to a saving of many thousands of tons of copper in a year, and less expensive metals are now brought into use as constituents of various fuses and other shell compounds.

A large amount of attention is being given to the question of health of munition workers, and principles are being established which will continue to be applied long after the war. More than 600 firms have appointed supervisors whose sole duty is to promote the welfare of their workers, and great benefit has resulted in different directions. Should they be necessary, schemes have been prepared in connection with the feeding of munition workers which have regard to the arduousness of the labor in which they are engaged. Last year the problem arising out of the handling of poisonous explosives (T.N.T. in particular) became somewhat acute, and a special committee was appointed to investigate them and make reports. This resulted in the application of suggestions which have been accompanied by an enormous diminution in the cases of illness. It has been found here, as in many cases before, that the problems of prevention when understood are simpler than those of cure.

The widespread employment of women in munition work has been accomplished with singularly little difficulty. From 60 to 80 per cent of the machine work on shells, fuses and trench-warfare supplies is now being performed by women. They have been trained in aeroplane manufacture, in gun work, and in almost every other branch of ammunition work. Also a large amount of mobile labor, not previously trained, has been utilized. For this purpose training supplementary to that which goes on in the works had to be resorted to. More than sixty technical schools and colleges in Great Britain are used in this work and have trained more than 32,000 workers. There are also five special industrial factories engaged in training. Three other sections of the Ministry of Munitions have been in constant operation to supplement that which is done either by dilution or training. There are 38,000 skilled work people employed away from their homes as war-munition volunteers and also 40,000 soldiers who have been released from the colors and have placed themselves at the disposal of the Ministry.

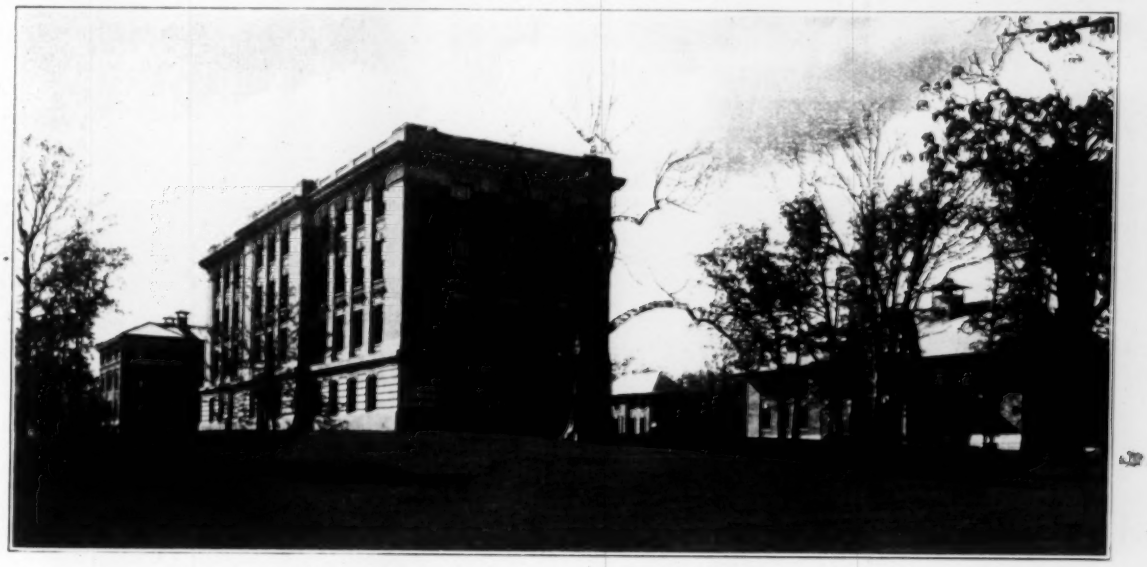
The Engineering Council has organized a committee known as the War Committee of Technical Societies. This committee is "to act as the intermediary or means of communication, when desired, in matters relating to Science, Research, Invention and Engineering" between the many and varied agencies of the Government and the membership of technical and engineering societies. It is hoped that by this means members of technical societies who as yet have not actively engaged in war work will allow their technical and engineering abilities to be drawn upon.

One of the first activities of the committee was to send to the membership of the technical societies the first bulletin issued by the Naval Consulting Board, under date of July 14, 1917, on The Submarine and Kindred Problems. Each member receiving the bulletin is urged to concentrate his best efforts upon the problem and to transmit any valuable ideas to the Secretary of the Naval Consulting Board.

U. S. BUREAU OF STANDARDS

THE U. S. Bureau of Standards is now doing work of exceptional interest and importance in connection with the war activities of the country. From time to time mention is made in the press of its new great laboratory for testing aircraft engines and of its work for the U. S. Army and Signal Corps. Of course, the greater part of this work is, as it should be, confidential.

But in addition to these special activities, the Bureau of Standards is carrying on many investigations of profound interest to the engineering profession. Thanks to the courtesy of Dr. S. W. Stratton, Director of the Bureau of Standards, and his staff of assistants and investigators, THE JOURNAL is enabled to present to its readers, beginning with the present issue, data on such of the work of the Bureau as is considered suitable for publication.



U. S. BUREAU OF STANDARDS

THE LATENT HEAT OF VAPORIZATION OF AMMONIA, Nathan S. Osborne and Milton S. Van Dusen

The latent heat of vaporization of liquid ammonia has been determined throughout the temperature interval —42 deg. to + 52 deg. cent. by direct measurements, using a calorimeter specially designed for the particular problem. This instrument is of the aneroid or unstirred type, the ammonia being the only liquid in the calorimeter. Heat developed and measured electrically in a coil is transmitted by conduction and convection to the ammonia, and is expended in the evaporation of a determined amount which is withdrawn as superheated vapor. Accessory data from other sources are required only in the computation of small correction terms. The results are expressed by an empirical equation and a table of values given for every degree from —45 deg. cent. to + 55 deg. cent. By combining the data for the heat of vaporization with the data for specific heat of the saturated liquid from a previous investigation, the specific heat of saturated ammonia vapor is obtained and a table of values of this quantity is given in an appendix.

CONSTITUTION OF PORTLAND CEMENT

In order to determine what new constituents are produced in portland cement when the magnesia content is raised considerably above that permitted by present standard specifications, and in order further to determine what effect these new constituents would have upon the physical properties of the material, a number of cements were burned in the rotary kiln of the Bureau. In these the magnesia content varied from 1.7 per cent to 25.5 per cent. In all 18 different cements were produced in two series of nine burnings each. In both series the compositions were those of normal cement, excepting the magnesia content only. But in one case the silica content was somewhat higher and the alumina content somewhat lower than in the other case.

As raw materials, clay, kaolin, feldspar, limestone and dolomite were used. In the one series the cement of lowest magnesia content was made of a raw mix containing limestone, clay and a small amount of feldspar, the latter being added to increase the silica-alumina ratio over that obtainable with clay and limestone alone. The magnesia in the other burns of this series was increased by replacing the limestone with dolomite. In the second series the raw mixes were composed of clay, limestone and a small amount of kaolin, the latter being used to decrease the silica-alumina ratio over that obtainable with the clay alone. In this series also increasing amounts of limestone were replaced with dolomite, until dolomite alone was used.

The deportment of the high-magnesia cements in the kiln was very characteristic. There was a reduction of the clinkering temperature with increasing magnesia content, though to produce satisfactory clinker this was not as marked as expected. But to prevent the dusting of the clinker of the higher-magnesia-content cements, it was necessary to overburn to a very hard vitreous mass. This mass in the kiln was about of the consistency of putty, and as a result there was a decided tendency to form "logs" and "rings." The clinker was also

of a reddish-brown color, which gave a decided brownish tinge to the ground cement.

A microscopical examination of the clinker showed that increasing amounts of magnesia produced an increasing size of crystals and granularity. When the magnesia exceeded 8 per cent, a constituent (monticellite) not present in normal cement was noted. When the magnesia was still further increased to an amount exceeding 10 per cent, another constituent—spinel—not present in normal cement, was also noted. It was also noted that those constituents—tricalcium silicate and tricalcium aluminate—which produced quick setting and early strength, were not materially decreased by the appearance of the new constituents; whereas, the orthosilicate of lime which produces the later hardening and modifies the early setting of the other constituents, was decidedly decreased in amount.

The effect of the higher magnesia, when not exceeding 8 per cent, was not very noticeable in any of the physical properties. Higher amounts produced a quick initial set and an apparent slow final set. The strength both in tension and compression of neat and mortar specimens, and of concrete specimens in compression, when 8 per cent was not exceeded, was very comparable with the strengths exhibited by cements of normal magnesia content. Above these amounts the early strengths were less, but show a consistent gain with age.

Specimens are still available for examination and breaking at later periods than those reported in this paper.

Tests of Large Bridge Columns, H. H. Griffith and J. G. Bragg

The investigation gives a comparative analysis of the experimental data found upon eighteen large bridge columns when they were tested in the 10,000,000-lb. testing machine. The action of each column, as a whole, was studied in a range of loadings taken to determine the behavior of lattice bars, pin plates, diaphragms, etc. The causes and effects of initial strain from riveting and fabrication are discussed.

Technologic Paper No. 10 of the Bureau of Standards.

Paints and Varnishes

This publication is intended to give, without unnecessary detail, information which should be of value to those interested in the use of paint and varnish. After a general discussion and classification of paints and varnishes and an explanation of the process of "drying," the raw materials, including oils, driers, thinners, resins, and pigments that enter into the composition of paint or varnish are individually described. The methods of manufacture and of testing varnishes are presented, ready-mixed or prepared paints are discussed, and somewhat detailed instructions on mixing paints and stains, on color blending, and on the application of paint and varnish to various surfaces are given. Specifications in common use for many of the materials treated are included, and a glossary of painters' terms also appears.

Circular No. 69 of the Bureau of Standards.

Materials for the Household

Describes the more common materials used by the household, comprising paint materials, cement, clay products, lime, plasters and stucco, wood, metals, bituminous roofing, inks, and dyes, adhesives, paper, textiles, rubber, leather, cleansers and preservatives, fuels, illuminants and lubricants, and concludes with a chapter on quantity in the purchasing of materials. Each title is treated under the general heads of composition and definition, sources, properties, uses, tests, preservation, hints as to selection and use, and references.

Circular No. 68 of the Bureau of Standards.

Combined Table of Sizes in the Principal Wire Gages

A table combining in one series the sizes in the American (B. & S.), Steel, Birmingham (Stubs'), British Standard, and Metric wire gages, arranges in order of diameters of wires. It gives the diameters of all the gage numbers in these five systems in mils, inches, and millimeters, also the cross-sections in square mils, circular mils, square inches, and square millimeters. The table is specially useful to manufacturers who wish to determine the nearest equivalent in American or British gage sizes of wires specified in millimeters or square millimeters, or vice versa.

Circular No. 67 of the Bureau of Standards.

The Determination of Absolute Viscosity by Short-Tube Viscosimeters, Winslow H. Herschel

The Engler and the Saybolt Universal viscosimeters, which are the instruments usually employed in the oil trade, have such short outlet tubes that the equation for the flow through long capillary tubes is not applicable without correction factors. The literature has been carefully reviewed and further experimental work has been done. The conclusion is reached that water is not a suitable liquid for use in finding the relation between viscosity and time of discharge for short-tube viscosimeters, and that Ubbelohde's equation, and all others based upon it, are seriously in error.

Technologic Paper No. 100 of the Bureau of Standards.

An Investigation of the Axial Aberrations of Lenses

In Scientific Paper No. 311 of the Bureau of Standards, the errors which affect the definition of a lens are discussed, and methods of graphically representing the central errors described. The condition for freedom from coma near the axis is arrived at. The relative importance of the errors in different types of lenses is discussed. Hartman's method is extended, permitting one set of measurements to give all the important central errors—spherical aberration, zonal variation of equivalent focal length, and axial and oblique achromatism. The apparatus and procedure are described, and the accuracy of the adjustments and the measurements discussed. The method is applicable to all systems of relatively short focus and large aperture, such as photographic lenses, projection lenses, and telescope objectives, and also to complete optical systems. The results of the method as applied to a complete telescope are discussed and shown to be independent of the accommodation of the observer. Seventeen sets of curves are given for as many different lenses, and an illustrative discussion of one set of curves, together with a general description of the types of lenses represented by each group of curves.

The Effect of the Size of Grog in Fireclay Bodies

The size of grain has long been known to exert considerable influence upon the properties of mortars, concrete, fireclay

refractories, and other materials. Technologic Paper No. 104 of the Bureau of Standards describes an investigation in which is determined the effect of the size of the calcined portion, or grog, upon the properties of the fireclay bodies within a field of practical sizes. The general plan of procedure consisted of separating grog into a number of sizes, recombining these in arbitrary proportions by calculation from triaxial diagrams, mixing with an equal weight of clay, and molding with water into test pieces for the determination of various properties. Strength in the raw state, as indicated by the modulus of rupture, depended upon a number of factors and did not vary directly with the size of the grog. Proper proportioning of grog sizes gave stronger bodies than single grog sizes. The strength of burned bodies increased directly with decrease of the size of grog, the size being expressed numerically as a surface factor. Bodies containing the larger sizes were more resistant to sudden heating and cooling from 600 deg. cent. and 1000 deg. cent. Volume shrinkage in burning to cone 12 increased approximately with decrease of porosity. No relation was found between strength and porosity in the dry or burned states. Methods are suggested for proper proportioning of grog for glass pots, saggers, and similar bodies.

Wave-Length Measurements in Spectra from 5600 A to 9600 A

Some work in spectroscopic analysis at the Bureau of Standards showed the importance of investigating the red and adjacent infra-red regions of spectra more carefully and extensively. Ordinary photographic plates were stained in a mixture of dicyanin, water, alcohol and ammonia to make them sensitive to the long light waves. These stained plates were used to photograph the arc spectra of twenty of the chemical elements, including the alkali metals, the alkaline earths, and elements commonly found in iron as impurities. The photographs were made in the first-order spectrum with a concave grating of 640 cm. radius, the grating being mounted in parallel light. This spectrograph gives a dispersion of about 10 A per mm. in the first order. With this apparatus exposure times of 30 min. sufficed to record waves longer than 9000 A (A = Angstrom = 0.0000001 mm.) and demonstrated the value of dicyanin as a photographic sensitizer for such spectral investigations. Waves which are 2000 A longer than the longest waves in the visible spectrum were thus detected photographically without difficulty.

Accurate measurements of wave lengths and determinations of the characteristics of the emission lines were obtained from these spectrograms. The second order spectrum of the iron arc was photographed on either side of the first order and the long wave lengths were obtained from the standards in the iron spectrum. In this paper the wave lengths in International Angstroms are given for the arc spectra of the following elements: lithium, sodium, potassium, rubidium, cæsium, copper, calcium, strontium, barium and magnesium.

Frequency differences of doublets in the spectra of sodium, potassium, rubidium, cæsium and copper are shown by these wave-length measurements to be constant in most cases to one part in 100,000 in the number of waves per centimeter.

Comparison of the spectra made it possible to detect many impurities in the elements used for light sources. Still more extensive spectral investigations are required in the region of long wave lengths to identify all lines correctly. (W. F. Meggers, in Scientific Paper No. 309, Bureau of Standards.)

Typical Cases of the Deterioration of Muntz Metal (60-40 Brass) By Selective Corrosion

Brass of the type 60 copper and 40 zinc, which is used commercially in a variety of forms, e.g., wrought bolts, sheathing, condenser tubes, extruded forms, etc., often shows a kind of deterioration by which the metal changes its color to copper-red and becomes very weak and brittle although the shape and size apparently remain unchanged. This change of properties is due to a selective corrosion of the alloy, which has a duplex structure, when exposed to the action of some electrolyte, particularly sea water. This type of corrosion has been recognized by manufacturers and users of brass for some time; the numerous samples illustrating this kind of deterioration which have been submitted to the Bureau of Standards, however, showed the utility of a description of typical cases of such corroded brasses. The study of such types includes bolts, boat sheathing, condenser tubes, and parts which were corroded while under stress.

The examination of the microstructure shows clearly the method of the attack, the zinc-rich constituent being electrolytically "leached out," leaving a skeleton of weak, pulverulent copper in its place so that the piece becomes very weak and brittle. Later the second constituent may be attacked so that the whole specimen is converted into pulverulent "copper," the sample becoming so weak that it can be broken into fragments in the fingers.

Conditions which appear from the examination of corroded samples to accelerate this type of corrosive attack are: The microstructural composition of the alloy, contact with strongly electronegative metals, the effect of certain adhering deposits of basic zinc chloride resulting from the corrosion, the thoroughness of the annealing the sample has previously received, the temperature of the electrolyte, and the stresses to which the specimens are subjected during the corrosive attack. (Technologic Paper No. 103, Bureau of Standards.)

Capital and Labor in England

At the general meeting of shareholders of Messrs. Dorman, Long & Co., held in Middlesbrough, England, on July 31, Mr. A. J. Dorman, dealing with the future relations between Capital and Labor, said that many took a gloomy view of what was likely to happen after the war, but personally he was not one of those. He believed, if they were allowed to manage their own affairs, employer and employed in conference together would arrive at a happy conclusion. To his mind the problem to be solved was to settle the price at which the workmen would give their best labor free from all restrictions. It must be evident to all thinking men that no high wages could be paid except in return for efficiency and increased output. Given that, a settlement would be an easy matter, for the employer did not ask for increased hours and harder work—improved machinery would do the hard work. Under such conditions it is possible to pay higher wages and yet produce at lower cost. British manufacturers could assemble their material at less cost than most nations, and had shipping facilities second to none. They had received little or no encouragement to embark in large commercial undertakings, and their machinery had been allowed to become somewhat antiquated, but a new life was springing up within them, and, if only a fair understanding could be come to between Capital and Labor, he had no doubt that the new industries that had been brought into being would prove to be a source of great prosperity to the country and

enable it to hold its own in the markets of the world. For obvious reasons, there was not likely to be any great alterations in their returns during the continuance of the war, but when peace came it would doubtless bring with it a large demand for shipbuiding and constructional material, for which they would be well prepared.

Sixth Annual Safety Congress

The Sixth Annual Safety Congress of the National Safety Council was held at the Hotel Astor, New York, Sept. 10 to 14. Concurrently with the congress was held an exhibition of safety and sanitation devices at the Grand Central Palace. This exhibition is claimed to be the largest and most complete ever held. The work of the congress was divided into the following groups: Public Safety Division, Public Administrative or Governmental Division, Health Service and Industrial Relations Division, Transportation and Public Service Division, and the Industrial Division. The Transportation Division was subdivided into four sub-sections, viz.: Electric and Street Railways, Marine and Navigation, Public Utilities, and Steam Railroads. The Industrial Division was formed by the following sub-sections: Chemical and Rubber; Logging, Lumbering and Woodworking; Metals and Metallurgy, including Foundries, Iron and Steel Works; Mining and Quarrying; Automobile Manufacturing; Car Builders; Paper and Pulp; and the Textile Trades.

American Chemical Society

The meeting of the American Chemical Society, held in Cambridge and Boston, September 10-13, was, to a large extent, of the nature of a review of the great work done by American chemists since the beginning of the war and of the degree of preparedness for the days of peace, however distant. The meeting was well attended and attracted a considerable amount of attention throughout the country.

Arthur L. Day, Director of the Geophysical Laboratory in Washington, gave an address on the Establishment of Optical Glass Manufacture in America. Up to the time of the war this country was dependent on Germany and France for its optical glass. The details of manufacture could not be obtained by the American Government from the governments of England or France, as the processes were secret and not known to these governments. The problem which was there and then put up to the Geophysical Laboratory was to make a satisfactory glass out of American raw materials and to do it quickly. After careful figuring by the Army and Navy officials it was decided that six was the minimum of different kinds of necessary glasses. In this work the Geophysical Laboratory was assisted by the Bausch & Lomb Co.

The difficulties were many, both in the way of lack of information and securing proper raw materials, but they have all been gradually solved, and it is expected that with the knowledge now available a glass equal to any used in Europe can be made in this country.

William H. Nichols, chairman of the Committee on Chemicals of the Council of National Defense, presented an extensive address on the Work of the Committee on Chemicals. An organization with the view to securing proper chemicals has been taken up by the Washington authorities since the declaration of war. The present organization is, in the opinion of the speaker, temporary. In all, the Chemical Committee with its sub-committees includes some 37 men, practically all of whom are leading men in their respective branches of industry. In general, the manufacturers have responded most cordially to the demands made upon them by the committee, and there are many instances of sacrifices being made for which recognition is not expected and will, probably, not be received. There are exceptions, but every effort is being made to produce satisfactory results without resorting to higher authority.

The one great need of any colossal organization is the complete coördination of all its parts. No one can claim that the organization in Washington has yet reached this stage or even approximated it. Many things are done several times over and many others needed are not done at all.

Dr. M. T. Bogert presented an address on the Work of the Chemistry Committee of the National Research Council, reviewing its activity in the mobilization of research chemists in war work. The most important field of their work is in the production of poisonous gases, gas masks, gas shells, the absorption of hydrogen gas in the submarine battery rooms, and the related U-boat problems.

Among the divisional meetings, one of the most interesting was the conference held by the Industrial Division on the Industrial Chemist in War Time. Dr. L. H. Backeland, member of the Naval Consulting Board, gave a talk on the Work of the Board. On the whole, there was little encouragement in what he said. The overwhelming majority of the suggested ideas are not worth much, and it has been necessary to issue a pamphlet telling the people what not to do. He said *new* explosives are not what is wanted, but a good supply of those we already know about.

In connection with the meeting a national exposition of chemical industries was held during the week of September 24, an account of which will be given in a later issue of THE JOURNAL.

An interesting report on the last meeting of the American Chemical Society will be found in the September 15 issue of *Metallurgical and Chemical Engineering*.

American Association of Port Authorities

Better coördination of terminal facilities back of the docks in American ports bears a close relation not only to reducing the cost of manufacture and the expense of living, but to the economic struggle that is coming after the war. In fact, the elimination of duplicated work and its consequent delays may mean much toward bringing peace in the war now being waged. This preparation for the present fight and the war after the war was emphatically advocated at the convention of American Association of Port Authorities in Cleveland, September 11 to 13.

The enthusiastic reception of this idea showed that the speakers were not alone in placing this interpretation and this emphasis on the resolution calling for increased efficiency of railroad freight terminals connected with ports. The resolution was carried over from last year's convention at Montreal.

The convention was opened Tuesday morning with an address of welcome by E. S. Griffiths, of the Cleveland River and Harbor Commission. This speech was responded to by the president of the association, W. G. Ross, of Montreal. The delegates were entertained at a luncheon reception by the Chamber of Commerce. Officials of the chamber, of the city and of the association made brief talks, and Calvin Tompkins, of New York, former commissioner of docks in that city, was introduced as the principal speaker.

Mr. Tompkins spoke of the way in which the world's shipping is now being administered as a great unit, with an efficiency never before attained. This work shows what can be

done and what probably will be done, at least in a measure, after the war is over.

Papers were read during the day on the following subjects: Establishment of Exact Lines for Port Planning, by Charles W. Staniford, chief engineer of department of docks and ferries, New York City; Administration of New York Canals, by Maurice W. Williams, engineer in charge of mechanical equipment of barge canal terminals; Legal Status of Submerged Land and Littoral Ownership, by Judge Robert M. Morgan, common pleas court, Cleveland. Colonel Lansing H. Beach, United States Engineers, described canal operations in various parts of the country.

How water-borne traffic on the Great Lakes has grown in about half a century from a few small cargoes to one of the greatest tonnages in the world, was interestingly told by Harvey D. Goulder, general counsel of the Lake Carriers' Association. In 1679 the *Griffin*, of about 45 tons, was built just above Niagara Falls. She made one trip and was never heard from again. In the following century a few small vessels appeared. In the forties of the past century a great statesman, in speaking against a land grant for a canal to connect Lake Superior with the lower waters, said one might as well propose to project commerce up into the moon as into the upper lake region. A few years later the state of Michigan made the improvement and the freight movement through the Soo that year was 14,563 tons. In 1916 it was 92 million tons.

The general opening of navigation, Mr. Goulder said, might be fixed as 1855, the date of the opening of the canal. Until after the Civil War the government had spent some $3,000,000 on lake navigation improvements. Since then it has spent more than $100,000,000. The great growth of lake freight was accomplished through a gradual growth in size of ships, canals and terminals.

This growth has resulted in cheaper manufactured products not only along the lakes, but in every part of the country, for the cost of carrying grain and ore on the lakes is only about one-tenth the average cost on the railroads.

In the evening an illustrated lecture on the handling of bulk freight on the lakes was given by J. D. Carey, of the Cleveland River and Harbor Commission. He explained with motion pictures how remarkable speed in loading and unloading ships is accomplished through big terminal equipment. By means of grab buckets that pick up in one stroke 15 to 20 tons of ore, a ship of 10,000 tons capacity can be unloaded in 3 hr. 15 min. The same ship can be loaded with ore in 25 min.

The Wednesday session was devoted to the discussion of the resolution adopted at the Montreal convention a year ago, calling on the Interstate Commerce Commission to investigate terminal and port conditions, railroad charges, free wharfage and kindred subjects, and bringing out the need for increased terminal efficiency through pooling and joint use of terminals. This matter had already been taken up with the commission since the previous convention, and is to be considered still further. The investigation probably will be made.

The discussion was opened with a general presentation of the problem of port terminal efficiency in its relation to the economic situation in the Americas and to the preparation for trade expansion when peace comes, by Edward F. McSweeney, of Boston, who first introduced the resolution. Millions of dollars have been spent on docks, he said, but much of it was wasted because there was little vision in planning. Facilities back of the docks were in isolated groups, controlled by separate railroads. Duplication of work and delay and congestion resulted.

In the war after the war—the struggle for foreign trade—the United States must put forth a united effort to win the share of commerce it needs and can supply. The value of this effort will depend largely upon our port arrangements.

The situation in regard to terminal charges and delays was taken up more in detail by Robert Bridges, of Seattle, in a description of that port, where a strong effort is being made to remedy faults. He explained how at several piers it takes 24 hours and costs $6 to transfer a car from one pier to the next, while with one belt line for the entire port, the same operation could be done in 30 min. for $2.

Mr. Bridges advocated not only the public ownership or direction of a belt line along the docks and a complete terminal yard, but centralized control of all railroads and the establishment of free ports. Any reduction in the time of handling freight would result in cheaper costs and quicker deliveries, and thus would attract many more factories to the port cities, the natural meeting place of raw materials, Mr. Bridges said.

W. G. Ross, Montreal, was reelected president; William J. Barney, of New York, secretary, and Harry C. Gahn, Cleveland, treasurer.

The next convention will be held in Boston next September.

Wm. J. Nolle.

New England Water Works Association

The Thirty-sixth Annual Convention of the New England Water Works Association was held in Hartford, Conn., September 11 to 15. The choice of Hartford as a place of meeting afforded a splendid opportunity for the study of the extensive new Water Works of that city now nearing completion. An interesting program, including addresses by specialists on problems of water-works design, construction, and management, was carried out.

Hon. Frank A. Hagarty, Mayor of Hartford, extended the greetings of the city, and commented on the extensive provisions for water supply for Hartford. Hon. Charles H. Clark emphasized the economy in water consumptions due to metering of water and made a plea for the treatment of municipal waste before its introduction into public water courses. Hon. Charles E. Goss advocated a dual water supply for cities—one serving domestic and the other industrial needs.

In his presidential address Mr. Caleb M. Saville, Chief Engineer of the Water Department of Hartford, outlined the qualities demanded in water-works executives and emphasized the necessity of broader training in the financial and economic aspect as well as design and construction of water works.

George A. Johnson discussed exhaustively the problems of rapid sand filtration and pointed to the ascendency of the mechanical or rapid sand filter. He called attention to the fact that 74 per cent of the filtered water in this country is supplied by rapid filters. He also pointed out the great diminution in typhoid during the last three decades and ascribed it in large part to water purification.

In the discussion which followed this paper the topics of prevention of tastes in waters treated with sulphate of alumina and the conservation of wash water were discussed by R. S. Hastings, W. C. Hawley, and others.

Robert S. Weston reviewed the development of mechanical filter bottoms and strainer systems and discussed in detail the advantages of the Wheeler strainer, particularly the elimination of metal parts, securing a uniform distribution of wash water and a minimum thickness of gravel. The care and operation of rapid sand filters formed the subject

of a paper by John W. Gaitenby, while a paper by F. L. Cady described the slow sand filters in use in Providence, R. I. Delos F. Wilcox described the problems encountered by the city of New York in dealing with the five privately owned companies within its city limits.

Bertram Brewer explained the means employed for reducing water rates in Waltham, Mass.

Papers on water-works shop construction were delivered by A. E. Martin and H. W. Hosford. H. R. Turner described the operating problems of a small Water Works Department.

A paper on the control of Microscopic Organisms in Water Supply by William Haine was warmly discussed.

After a general exposition by President Saville of the water system of the city of Hartford, a detailed description of the system was given by the members of the Engineering Staff. Particularly interesting were the descriptions of the construction of the Masonry Dam on Nepaug River, the design of Spillway at Richard's Corner Dam, Grouting of Dam Foundations, and the development and designing by H. W. Griswold, R. E. Wise, J. E. Garrett, W. E. Johnson, Frank Brainard, H. W. Horne, and J. H. Shaughnessy.

In dealing with the subject of Pollution of Streams in Connecticut, J. L. Jackson deplored the failure to restrict the discharge of wastes into streams which might otherwise be excellently adapted for drinking purposes.

S. E. Killam outlined the means by which Boston was enabled to postpone by many years its proposed extension to its water system by reducing its per-capita consumption from 109 to 80 gal. per day, through the installation of service meters.

The papers will be published in full in the Quarterly Journal of the New England Water Works Association.

Gravitation

In the daily papers of September 19 it was stated that a new theory as to gravitation will be announced soon before the St. Louis Academy of Science by Prof. Francis E. Nipher, retired head of the department of physics of Washington University. In a written statement Professor Nipher said:

"It will be shown that gravitational attraction between masses of matter not only has been diminished into zero, but has been converted into a repulsion which is more than twice as great as normal attraction."

Professor Nipher is reported to have made his experiments with bodies suspended horizontally toward each other. By introducing electricity into the atmosphere he converted normal attraction into repulsion.

"If electricity can alter the gravitational attraction of the bodies used in my experiments," he said, "the same force can alter the earth's attraction. If the negative electricity could be drawn from the earth's surface, gravitational attraction suddenly would cease and the coherence of the earth's surface would be disastrously affected."

This Month's Abstracts

A. Leon, in the *Journal of the Society of German Engineers*, discusses the subject of fatigue of machine parts, more particularly the distribution of stresses in machine parts at points where the section of the members concerned becomes wider or narrower.

The variation of temperature in dams of various thicknesses during the period of setting in concrete forms the subject of an investigation by R. A. Monroe. He found that first this variation is different in thin arches from that occurring in thick arches, and second, the temperature of a concrete wall of light thickness (14 in.) follows that of the air with remarkable closeness.

The Bureau of Standards has investigated, with characteristic thoroughness, some unusual structures of wrought iron apparently due to the presence of a high content of phosphorus. One of the remarkable characteristics of the structure investigated is its persistence upon heating, which suggests a possible bearing on the failure of material in which it occurs.

Description of apparatus and processes for testing rails by the quick-bend method as carried out by the Pennsylvania Railroad will be found in the section Engineering Materials. It is stated that this method displaced the drop test formerly used, because the now nearly universal use of open-hearth steel rails has made necessary a method which, in addition to detecting possible brittleness, would also determine the ranges of elasticity and ductility of the steel.

Data on the spark length in various gases and vapors are presented by Robert Wright in a paper in the *Journal of the Chemical Society*. This appears to be the first investigation of this kind of electric ignition carried out under conditions enabling comparable results to be obtained.

Another feature of the design of internal-combustion engines is covered in an interesting manner in an article on bulb experiments in hot-bulb engines published in *The Engineer*. The article discusses the design of the hot bulb and reports experiments with various types of this important auxiliary.

The McEwen high-compression oil engine described in the section Internal Combustion Engineering operates on the Diesel principle. Its interest lies primarily in the fuel valve and method of governing fuel injection, and in the design of a comparatively simple air compressor.

The paper by William Alexander before the Institution of Mechanical Engineers describing the energy diagram for gas mixtures in British units and some of its uses is of considerable interest, and would have been still more valuable had the actual charts been reproduced. As a matter of fact, however, the only chart reproduced is the combined chart of entropy temperature and entropy total heat as found in the abstract in this issue. The writer derives expressions for the various relations affecting the energy derivation in the gas mixture, and in addition gives, by way of illustration of the use of the diagram, some data on the comparison of thermal diagrams for large and small Diesel engines. This part of the paper is of considerable interest in itself, but could not be abstracted here because of lack of space.

Alan E. I. Chorlton's extensive paper on the construction of turbine pumps could be only briefly abstracted. It is particularly interesting because of the careful classification of the various types of turbine pumps under the headings of the varions component parts of a pump. It is interesting to note that the writer does not believe that the so-called balanced-type of single-eye wheel of multicellular pumps is actually balanced, and claims that the advantage of being in balance is a purely paper one. Disturbing factors are set up for various influences, and in practice it is necessary to provide additional balancing means of one type or another.

A 120-ton coal car for the Virginian Railway, described in the section Railroad Engineering, is of interest not only because of its huge size, but also because of some features of construction which made the use of such a large unit possible and safe.

REVIEW OF ENGINEERING PERIODICALS

SUBJECTS OF THIS MONTH'S ABSTRACTS

FATIGUE OF MACHINE PARTS.
INITIAL AND ALTERNATING STRENGTH OF MACHINE PARTS.
NOTCH FIGURE IN MACHINE PARTS.
UTILIZATION FIGURE IN MACHINE PARTS.
TEMPERATURE VARIATION IN DAMS DURING SETTING OF CEMENT.
UNUSUAL STRUCTURES IN WROUGHT IRON.
OCCURRENCE OF INTER-CRYSTALLINE STRUCTURE IN WROUGHT IRON.
TESTING RAILS BY QUICK-BEND METHOD.
PENNSYLVANIA RAILROAD MACHINE FOR TESTING RAILS BY QUICK-BEND METHOD.
DROP AND QUICK-BEND TESTS OF RAILS COMPARED.
SPARK LENGTHS IN VARIOUS GASES.
MCEWEN HIGH-COMPRESSION OIL ENGINE.
HOT-BULB ENGINE EXPERIMENTS.
ENERGY DIAGRAM FOR GAS MIXTURES IN AMERICAN UNITS.
THERMAL DIAGRAMS FOR LARGE AND SMALL DIESEL ENGINES COMPARED.
THEORY OF FLEXIBLE-TUBE MANOMETER.
COLUMN FORMULÆ.
BUREAU OF STANDARDS SYMBOLS FOR SCREW-THREAD NOTATION.
TURBINE-PUMP CONSTRUCTION.
BEACH OIL-ELECTRIC CAR.
120-TON COAL CAR, VIRGINIA RAILROAD.
STRESS LIMITATIONS IN VIRGINIA RAILROAD COAL CAR.
PERMUTITE, EXCHANGE OF BASES IN.
SUGDEN'S SUPERHEATER FOR STIRLING TYPE OF BOILER.

Engineering Materials

FATIGUE OF MACHINE PARTS, A. Leon

(*Zeits. Vereines Deutsch. Ing.*, vol. 61, pp. 192-196, March 3, and pp. 214-218, March 10, 1917.)

The common assumption that pure tension or compression is distributed uniformly over the whole section, and that the variation of stress is linear in the case of bending, is not justified where the section of the members concerned becomes wider or narrower. There the nature and distribution of stress are complicated, and this is an important factor in machine parts, especially in moving parts of complex form which are subjected to alternating stresses. A notched test bar loaded gradually to the breaking point behaves differently according as the metal is brittle or ductile. In brittle materials the distribution of stress remains uneven until fracture occurs (at lower load than corresponds to the strength of a smooth bar of the material). A ductile material, on the other hand, gives greater strength when notched than when in the plain bar; once the yield point is passed, the extension increases rapidly and the stresses are equalized to an increasing extent. Cross stresses are also set up which reduce the risk of breaking. The author gives curves and formulæ relating to longitudinal and cross stresses, and changes in the corresponding dimensions of a notched rubber rod. A notched rod of ductile material does not contract over the whole breaking section, but only in the immediate neighborhood of the slot bottom. The section after fracture is relatively less contracted than in a smooth rod, hence the greater breaking load. Under repeated, and particularly under alternating, stress, ductile material behaves like brittle material; where the limit of elasticity is exceeded, the material is given a "set" first in one direction, then in the other. As a result it becomes fatigued, small cracks appearing which gradually deepen and extend until failure occurs. Wöhler's tests show the danger of sharp changes in section. St. Venant showed that notching causes local increases in pressure of at least 100 per cent. Failure under alternating load occurs at a point where the stress distribution is affected unfavorably by a hard or soft inclusion, or by complete interruption of the elastic cohesion. Heating of specimens during alternating-stress tests is an indication that the elastic limit is being exceeded, so that inelastic changes in form are occurring and failure will soon take place. In order to tell whether the elastic limit will be exceeded in a constructional part, it is necessary to know the actual distribution of stress. Alternating tensile and compressive stresses up to about 85 per cent of the elastic limit, or 45 per cent of the ultimate tensile strength, do not cause failure of mild steel until the number of load reversals exceeds 1,000,000; the rapidity of reversal of the load also affects the life test. The author mentions Beilby's hypothesis of an amorphous modification of the metal as a possible explanation of fatigue phenomena. Ludwik suggests a loosening of the metallic structure by repeated stressing. Under alternating torsion the change in form is localized more and more until only a single layer of material is "working"; this intensifies local variations in stress and increases the risk of fracture.

Bauschinger's tests on various grades of iron show the ratio of steady tensile strength to initial and to alternating strength to be 1 : 0.56 : 0.49. In other words, the initial strength is only about 14 per cent greater than the alternating strength. The author defines "notch ratio" as the ratio of greatest to smallest width of rod; and the "notch figure" as the ratio of greatest mean stress (referred to the useful section). The reciprocal of the notch figure is the "utilization figure." A circular hole in a plate causes 200 per cent increase in stress at two points on the edge of the hole, i.e., the notch figure is 3, compared with 8/3 for semicircular edge notches. The author cites values for these factors as determined by various investigators, and gives curves for the stress distribution in a perforated rubber rod subjected to tension. Comparison is made between mild steel subjected to small distortion and rubber subjected to great extension. The author gives tables of data from his own tests on rubber rods, and local and average extension. The large deformation in rubber specimens equalizes stress distribution to some extent. For instance, with a notch ratio of 5 the notch figure decreased from 3.15 to 1.98, corresponding to mean extensions of 11 and 37 per cent and maximum local extensions of 36 and 75 per cent. Curves in the original show the distribution of primary and secondary stresses in a perforated stone block subject to compression, and in a rubber specimen with rectangular holes. The secondary (cross) stresses are important. These tests have a bearing on the influence of rivet holes on the strength of parts. Fillets may affect stress distribution unfavorably, and examples in the original show the proportion of various sections which is rendered idle by ribs or fillets. The final section of the paper includes a number of useful notes concerning the effect of various changes in sections, slotting, polished or ground surfaces, and various means of observing these effects and compensating for them. The paper relates rather to the general phenomena and problems of stress distribution than to specific machine parts. (*Science Abstracts*, Section B—Electrical Engineering, vol. 20, part 7, July 30, 1917, no. 235, pp. 225-226, *t*)

How Temperature Varied in Two Dams While Cement Was Setting, R. A. Monroe

In planning the recent 40-ft. height increase of the Lake Spaulding dam of the Pacific Gas and Electric Company in northern California, it was decided to determine how temperatures varied within the concrete. Accordingly, as the work was under way, thermometers in the shape of thermocouples were put in at predetermined locations, so that records could be kept. The same tests were applied to a dam of the multiple-arch type in order that the effect in thin arches might be compared with that observed in a structure of large section.

In the large dam the thermometers were located both at the center and near the surface, while in the thin arches only a central location was used.

The data are presented in the form of tables. From them it is seen that the temperature of the freshly placed concrete was 47 to 48 deg., and in eleven days it rose noticeably across the entire section. At the upstream face the gain was 27 deg.; at the downstream face, 22.5 deg., and at the center 43 deg., or, roughly, twice as much as at the faces. (These data refer to the Spaulding dam.) In two months the temperature of the concrete 1 ft. from the faces of the dam had returned to normal atmospheric temperature, while that of the center of the section was still 20 deg. above normal atmospheric temperature, and falling at the rate of 3 deg. per week. A reading taken over six months from the time of pouring showed the concrete at the center to be 4 deg. above that at the faces, but at practically mean atmospheric temperature for the preceding month.

The results in the case of the thin arch were different. In the design of the arch it was assumed that due to the chemical action of the cement the setting temperature of the concrete in the arch wings would be 10 deg. above the average daily temperatures. Actually, a rise of 17 deg. above the mean was discovered. The results as presented in a table also show that the highest temperature was attained in about 18 hours after pouring, or shortly after the concrete had taken its permanent set, but that this temperature was maintained for only a few hours.

Another interesting thing which was noted was how closely the temperature of a concrete wall of this thickness (14 in.) follows that of the air, and these results indicate clearly that in a structure of this type provision must be made for a temperature variation of approximately the same magnitude as shown by atmospheric records. (*Engineering News-Record*, vol. 79, no. 6, August 9, 1917, pp. 253-254, 3 figs., *e*)

Some Unusual Structures of Wrought Iron, Henry S. Rawdon

Data of an investigation carried out at the U. S. Bureau of Standards in which sections of wrought iron which have failed have been investigated chemically and microscopically, and as a result attention is called to the detection of certain impurities and their possible influence on the physical properties of the metal.

As a rule, in wrought iron no definite orientation of crystals, or grains, is apparent, but the presence of slag in the ferrite matrix is usually revealed by the appearance of streaks.

In some cases, however, the ferrite crystals presented a mottled appearance, particularly after prolonged etching with an acid reagent. This etch pattern was not found over the entire surface of the specimen, but was restricted to certain streaks throughout the metal. Particularly was it found associated with crystals unusually large in size.

By using a copper-chloride etching reagent these patterns may be developed in a striking manner. Crystals of ordinary wrought iron will not exhibit such etch patterns even after very prolonged heating.

The examination of the metal close up to the fracture which occurred during its service shows that the break took place through the crystals and parallel to the markings constituting the mottled etch pattern at that point.

The writer comes to the conclusion that the non-homogeneity of the individual crystals as indicated by the mottled etch pattern is to be attributed to some impurity dissolved in the iron, but not uniformly diffused throughout the crystal.

An examination of several pieces revealed that the unusual microstructure described above is found only in material relatively high in phosphorus, but analysis for phosphorus shows that though such unusual features of structure are invariably associated with irons which are rather high in phosphorus, one cannot predict with certainty their presence from a knowledge of the average phosphorus content alone.

One of the remarkable characteristics of this inter-crystalline structure is its persistence upon heating. After heating a specimen of a wrought iron eyebar for three hours at approximately 600 deg. cent., no appreciable change in structure was found. A second sample heated for about one and a half hours at approximately 725 deg. cent. and furnace-cooled still shows faint traces of the former condition.

The eutectic disappeared, but the non-homogeneity of structure is still apparent from the dendritic pattern. This illustrates the remarkably slow rate of diffusion of phosphorus in the ferrite matrix, and explains why the mottled structure is not wiped out during the processes of heating, rolling and forging constituting the manufacture of wrought iron.

These unusual features of microstructure suggest a possible bearing on the failure of material in which they occur. The brittle character of ferrite containing considerable phosphorus is well known. Crystals which show the heterogeneity caused by high- and low-phosphorus bands in juxtaposition are more apt fatigued by repeated stresses than crystals more uniform in their structure. This applies particularly to bands transverse to the direction of the stresses acting.

Examination of a series of wrought irons showed, however, that such features are not to be regarded as common. Many poor grades of iron may be unsuitable for other reasons. (*The Iron Age*, vol. 100, no. 10, September 6, 1917, pp. 538-540, 7 figs., *t*)

Testing Rails by the Quick-Bend Method

Description of an apparatus recently built by the Pennsylvania Railroad to replace the drop test. The Pennsylvania Railroad introduced the present drop test into its specifications for carbon-steel rails in 1900, at which time the rails were produced by the bessemer process only and brittleness was to be guarded against. Since 1908, however, open-hearth-steel rails have come into general use and at the present time practically all orders for rails on the Pennsylvania Railroad are of this nature.

On the open-hearth rail, however, the drop test gives very little information on the relative merits of rails from different manufacturers. It was therefore thought that a transverse rapid-bending test as an alternative to the standard drop test might give more conclusive information relative to such

physical properties as elasticity, ductility and hardness of the material.

The quick-bend test machine was placed in service about May, 1917. It consists of a hydraulic press and intensifier. The press is of the four-column inverted type, having a clear distance of 3 ft. 4 in. by 12 in. between columns. The main ram, 16 in. in diameter with a 12-in. stroke, is cast solid with the moving platen, which is guided on the four columns. The twin pull-back rams, 6 in. in diameter, are symmetrically located at the sides of the main ram.

The intensifier (Fig. 1) is of the single-pressure type with a total weight of approximately 11,000 lb. The ram which extends from the high-pressure cylinder to the base-pressure cylinder is integral with the base-pressure piston and has a total stroke of 36 in. The diameters of the ram and the base-pressure piston are 9 in. and 26 in. respectively, which gives a step-up ratio of about 8.35 to 1.

The operation of the machine is controlled by a bronze three-way valve having a balanced exhaust. By admitting 450 lb. per sq. in. line pressure to the base cylinder of the intensifier, the pressure in the high-pressure cylinder thereon and consequently in the ram cylinder of the press is raised to ap-

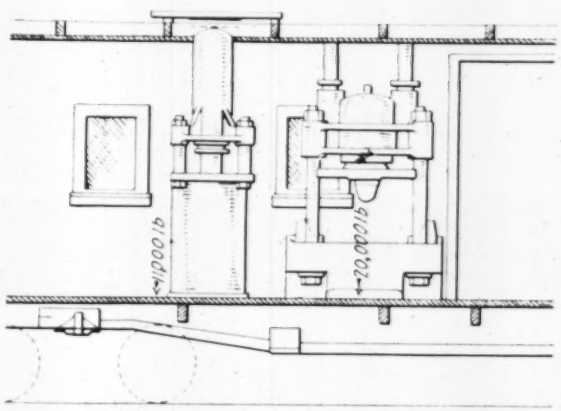


FIG. 1 PENNSYLVANIA RAILROAD MACHINE FOR TESTING RAILS BY RAPID BENDING

proximately 3760 lb. per sq. in., developing a total capacity in the press of about 756,000 lb. The 36-in. stroke of the intensifier ram actuates the entire 12-in. travel of the main ram by intensified pressure alone, thus assuring a smooth, continuous curve of the indicator card.

The hydraulic indicator is used to register the pressure required for a relative deflection of the specimen, the indicator being in direct communication with the main ram chamber.

The rail test specimen is placed on the supports of the press and pressure is applied through the loading head of the ram at the center of the rail until rupture of the specimen occurs. During this action, which requires approximately seven seconds, the indicator card showing increments of deflection and corresponding pressure is taken. In this card the curve is drawn of which the abscissae indicate deflections and the ordinates the loads in thousands of pounds. The elements taken from the card are the deflection and load at the elastic limit and the ultimate strength, while the work required to fracture the specimen may also be obtained.

It has been demonstrated from comparative drop and quick-bend tests that rails which have to meet the drop-test requirements showed undesirable physical properties when subjected to the quick-bend test. The quick-bend test is of particular advantage in the determination of the ranges of elasticity and ductility of the steel. (*Railway Age Gazette*, vol. 63, no. 10, Sept. 7, 1917, pp. 413-415, 3 figs., *d*)

Internal Combustion Engineering

SPARK LENGTH IN VARIOUS GASES AND VAPORS, Robert Wright

The different factors affecting the phenomenon of electric discharge, in so far as the length and nature of spark, voltage, gas pressure and temperature relations in the spark are affected, have formed the subject of a large number of investigations (compare THE JOURNAL for January 1917, p. 86), but the wider chemical relations have been investigated a good deal less.

Natterer, in 1889, published an examination of the spark discharge through a number of gases and vapors at atmospheric pressure. His method of investigation appears to have been, however, quite crude, and the data cannot be relied upon.

As regards the effect of temperature of the gas on the spark, Harris, in 1834, and Cardani, in 1888, both found that the temperature has no effect on the spark, provided that the number of molecules per cubic centimeter of the given gas remains constant. That is to say, if the spark gap be enclosed in a gas-tight vessel, then the voltage required to produce a spark will be quite independent of the temperature; but if the vessel be left open so that the gas can expand at atmospheric pressure, then increase of temperature causes increases of spark length for a given voltage. The effect is exactly the same as if the gas concentration had been reduced by lowering the pressure in the ordinary way, the temperature remaining constant. In the present investigation a 20-mm. gap at 100 deg. cent. was found to correspond with 15 mm. at 18 deg. cent. and 20 mm. at 183 deg. cent. with 5 mm. at 18 deg. cent.

TABLE 1 RELATIVE SPARK LENGTHS IN MILLIMETERS

Substance	Air gap 30 mm.	Air gap 20 mm.	Temperature, deg. cent.
Methane	29	20	100
Methyl chloride	24	16	100
Methylene chloride	9	6	100
Chloroform	5	3.5	100
Carbon tetrachloride	1.5	1	100
Methyl bromide	12	9	100
Methyl iodide	8.5	5.5	100
Ethane	24	18	100
Ethyl chloride	21	16	100
Ethyl bromide	9	6.5	100
Ethyl iodide	6.5	4.5	100
Ethylene	35	27	100
Acetylene	32	26	100
Water	40	36	138
Methyl alcohol	30	26	138
Ethyl alcohol	23	19	138
*iso*Propyl alcohol	18	15	138
*iso*Butyl alcohol	16	13	138
Ethyl formate	14	..	138
Ethyl acetate	11	..	138
Ethyl propionate	8	..	138
Carbon dioxide	16	11	100
Sulphur dioxide	10	6	100
Carbon disulphide	8	5	100
Hydrogen sulphide	17	12	100

In the present investigation the vapors of a number of simple organic substances were sparked under conditions enabling comparable results to be obtained. Among other things, a fairly constant voltage was arranged for by having an air gap of similar form and definite length coupled in parallel with the vapor gap, both gaps being at the same temperature. In each measurement the length of the vapor gap was adjusted so that on carefully raising the potential it sparked equally with the standard air gap. Thus the measurements may be taken as representing the insulating powers of the various substances relative to that of air at the same temperature and pressure.

It is interesting to note that for various reasons, fully explained in the original article, it was found advisable to abandon measurements made by comparing vapors at their boiling points with air at the same temperature. It was also found that, whether the air gap is heated or not, it is of the first importance that all vapors with which comparative measurements are being made should be at the same temperature.

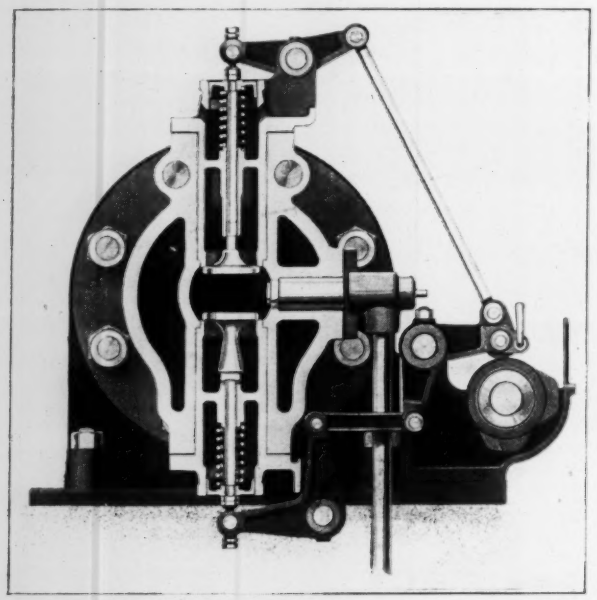


FIG. 2 SUCTION THROUGH VALVE CHAMBER OF MCEWEN HIGH-COMPRESSION OIL ENGINE

The apparatus used is described in detail. The results given in Table 1 have been obtained, but no claim for great accuracy is put forward, even though each figure is the mean of several readings which never varied among each other by less than 10 per cent. Still, for any series of comparable substances, increase of molecular weight is accompanied by increase of insulating power, but the method is not sufficiently accurate to determine whether the property is a purely additive one or not. In fact, it appears that the curves connecting the potential and length of spark for different gases may intersect one another, and this result was actually obtained in the case of carbon dioxide and air.

An attempt to measure the spark length for several of the substances in the liquid state proved to be a failure. However, one can scarcely expect that any simple agreement could exist in the case of liquids, for, first, the extra factor of surface tension has been introduced, and, second, the relationship between number of molecules and volume which holds for gases, no longer exists here. (*Journal of the Chemical Society*, vols. 111 & 112, no. 657, July 1917, pp. 643-649, 2 figs., *e*)

MCEWEN HIGH-COMPRESSION OIL ENGINE

The McEwen engine is of the four-cycle high-compression type which operates on the Diesel principle and is adapted to burn any kind of heavy crude oil or residue.

As shown in Fig. 2, the inlet and exhaust valves are vertical and the fuel-injection nozzle in the center of the head. The operating camshaft driven by a gear on the crankshaft is supported independently of the cylinder, so that the cam thrust is taken up directly by the engine foundation, thus relieving the frame of stresses from this source. To take off the cylinder head it is necessary only to disconnect the exhaust pipe and fuel line, knock out the pins on the valve levers and remove the nuts from the head bolts.

The piston is in one piece of the truck type and is air-

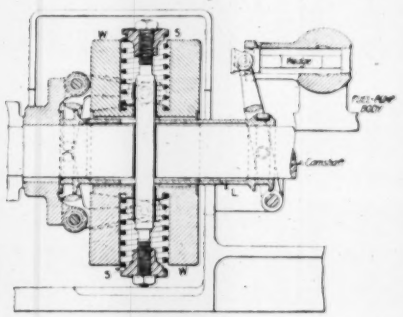


FIG. 3 GOVERNOR AND PARTS OF FUEL VALVE OF THE MCEWEN ENGINE

cooled. The length of the rod, and thus the compression, may be altered by inserting distance pieces between the rod and the boxes.

In the fuel pump no stuffing box is used, the plunger being

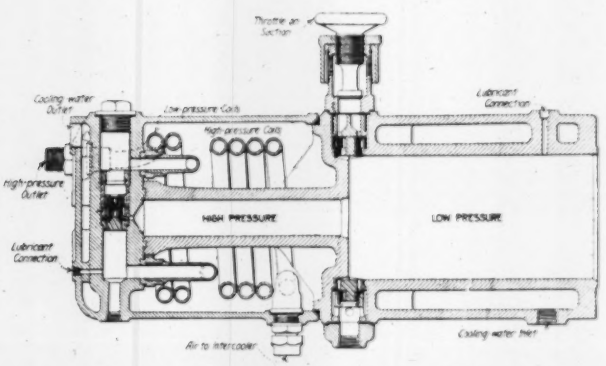


FIG. 4 AIR COMPRESSOR OF THE MCEWEN ENGINE

case-hardened and ground. This plunger is operated against a spring and the return stroke is controlled by a wedge which is actuated by the governor, Fig. 3.

This governor consists merely of the weights *W* held by spring *S* and connected by bell cranks to the sliding sleeve *L*, which in turn connects with the wedge. As the speed increases the weights fly out, causing the bell cranks to slide the sleeve to the right and shove the wedge in farther. This shortens the return stroke of the pump, decreases the suction, and feeds less fuel to the spray nozzle.

A two-stage air compressor self-contained in a single barrel is driven by a small crank on the end of the main shaft. As shown in Fig. 4, the first- and second-stage cooling coils are

integral with the combined high-pressure head and water jacket.

The high-pressure air goes to the fuel spray line which is provided with a seamless steel-tube receiver to prevent any fluctuation in pressure. The pressure and output of the compressor is controlled by a throttle on the suction line of the low-pressure end, and when it is desired to charge the starting tank this throttle is opened and the charging air taken off between the high- and low-pressure stages. The air starting valve is in the side of the cylinder head (see Fig. 2).

The cooling water first comes to the compressor, then is passed to the engine cylinder jacket and finally to the cylinder head. Neither the piston nor the exhaust valve is cooled. Based on 50 deg. fahr. entering temperature and 140 deg. fahr. exit temperature, the builders estimated a water consumption of approximately 3.5 gal. per hp.-hr. In rating the engine a conservative mean-effective pressure of about 68 lb. is figured on, allowing for 10 per cent overload for two hours. (It is stated that the engine actually carried for a short period as much as 25 per cent overload.) (*Power*, vol. 46, no. 10, September 4, 1917, pp. 321-323, 7 figs. *d*.)

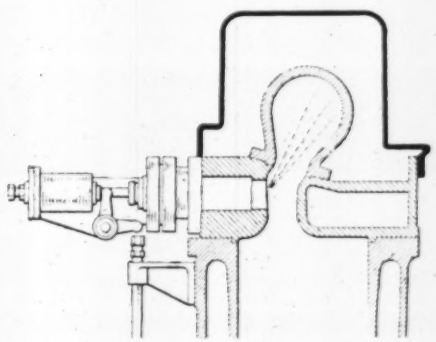


FIG. 5

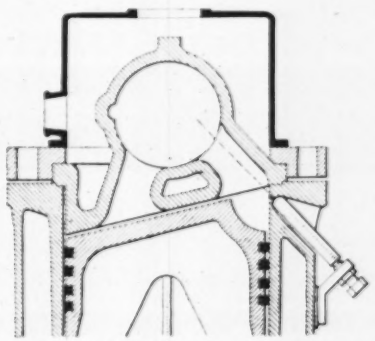


FIG. 6

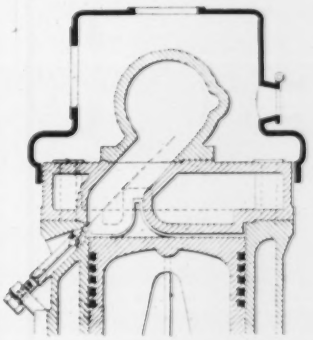


FIG. 7

FIGS. 5 TO 7 VARIOUS TYPES OF HOT-BULBS TRIED OUT WITH SOLID AND AIR INJECTIONS

SOME BULB EXPERIMENTS IN HOT-BULB ENGINES

With the hot-bulb engine it is always a matter of considerable difficulty to get absolutely complete combustion of the fuel oil. In all engines that inject the oil direct into the cylinder with a pump the oil enters as a jet, and as it is in a more or less solid form, it is extremely difficult to obtain smokeless combustion, owing principally to imperfect pulverization causing the particles of oil to be too large to burn completely during the short period the oil is in the cylinder. Further, if the nozzle is of an imperfect form there is also a danger of the oil carrying over too far and depositing on the sides of the combustion chamber.

With air injection it is possible to obtain greater turbulence and mixing in the combustion space, with the result that cleaner combustion is obtained.

The author [not named] carried out a series of experiments to determine the best form of bulb. Both air- and solid-injection systems were tried, and, while no absolutely uniform conclusions can be drawn from the experiments, forms of bulbs were determined that for certain classes of heavy oils are claimed to be smokeless.

It was also found that when new sizes of engines were built embodying the best results, some of them did not come up to expectations, while others exceeded the best that had been obtained, thus illustrating once more the statement that each size of each type of oil engine is a law unto itself.

Fig. 5 (of which only the top part is reproduced) shows a section of an ordinary crankcase compression two-cycle hot-bulb motor. The cylinder cover was water-cooled and the injection valve was placed horizontally in it, so that it was necessary to deflect the jet up into the bulb by drilling the nozzle hole at an angle.

For the air-injection type the form of bulb shown in Fig. 5 was found to be the best and most durable, and practically all classes of fuel could be smokelessly consumed. In addition, it was possible when the correct compression was found (about 140 to 150 lb. per sq. in.) to run at full speed without the aid of a water-drip to regulate the temperature of the bulb.

The water-cooled cylinder cover possesses an advantage that is very convenient should the supply of water give out. As the air is compressed into the bulb through a water-cooled throat, the temperature of the bulb can be kept within all practical limits, by regulating the temperature of the water around the throat.

In all designs of hot-bulb motors with water-cooled cylinder covers the bulbs are very small as compared to those (see Fig. 6) in which the bulb and cover are made as one uncooled casting. Bulbs are therefore very cheap to replace, and as the air in the cylinder is kept cooler by the cover, it is denser, and consequently a higher mean pressure can be supported and a more powerful engine obtained, which was proved by the experiments.

As regards the comparative merits of solid and air systems of injection, the writer states that it is safe to estimate an increase of 15 per cent in the power of air-injection over solid-injection engines, which compensates for the complications added by the compressor. On the other hand, it requires a more intelligent driver to operate the engine, and this type should only be installed when good attention can be given. It is also better adapted for the larger sizes of engines and it is the writer's opinion that it should not be fitted to engines giving less than 40 to 50 b.hp. per cylinder.

Practically speaking, any of the six forms of bulb illustrated in the article can be used for air injection with smokeless combustion, and further, it was found that the testing expenses and time required for tuning up was less for a new size of engine of this type than for a new size of the solid-injection type.

For the latter the form of bulb shown in Fig. 6 was tried, but even though it was used with success on a well-known

make of engine, it was found to be rather smoky. Further, the fact that a certain proportion of the air in the passage leading into the bulb furthest away from the jet cannot be directly attacked by the oil jet would, no doubt, tend to keep down the main pressure.

The type shown by Fig. 7 easily gave the best results despite possibly some serious drawbacks. With paraffin, shale oil and gas oil the exhaust was perfectly clean, full power was obtained without assistance of the water-drip, and no overheating of the bulb took place. With the water-drip an increase of 25 per cent in the power was easily maintained for long periods and without the expenditure of any additional fuel oil. The writer believes that this type of bulb keeps cool without the water-drip, because the whole of the flange of the bulb is in contact with the water-cooled cover.

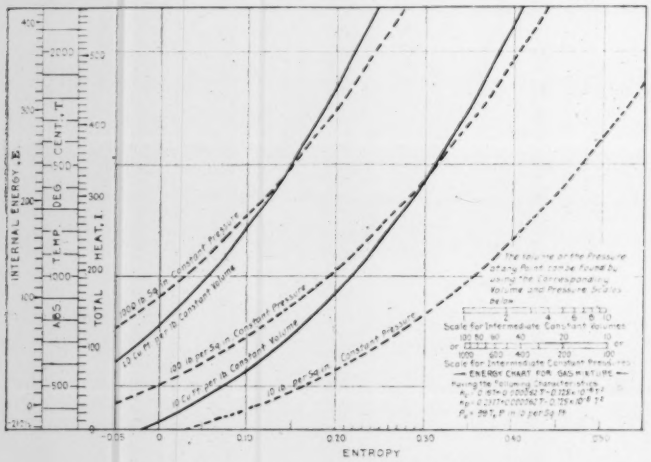


FIG. 8 COMBINED CHART OF ENTROPY TEMPERATURE (ϕT) AND ENTROPY-TOTAL HEAT (ϕI)

Should the bulb tend to keep too cool, its temperature can be nicely adjusted by relieving some of the flange, so as to reduce the surface in contact with the water cooling of the cover. The bulb proved to be very durable.

Two modifications of Fig. 7 were tried: one in which the nozzle was placed in the cylinder cover and much nearer to the bulb than in Fig. 7, and another with the bulb having one of the walls practically a prolongation of the throat to the cylinder. Both proved to be failures. Next, the nozzle was put directly in the bulb with no better success. The difference in the design of these types of bulbs is quite slight and is a good illustration of how small the margin is between success and failure in the design of hot-bulb engines. (*The Engineer*, vol. 124, no. 3215, Aug. 10, 1917, pp. 112-113, 6 figs., *e*.1)

AN ENERGY DIAGRAM FOR GAS MIXTURES AND SOME OF ITS USES, William Alexander

Charts have been published for the average gas mixture in metric units, namely, by Prof. A. Stodola, but these charts cannot be used with British units of pressure and volume. In view of these facts the writer prepared a chart expressed in British units and represented in it all of the six state characteristics of gaseous substances.

In the derivation of the chart and expression of equations on which it is based, the following notation has been used:

P = pressure in lb. per square foot, or

p = pressure in lb. per square inch

v = volume in cubic feet per lb.

T = absolute temperature (centigrade)

ϕ = entropy

E = internal energy

I = total heat, defined by $I = E + \frac{Pv}{J} = E + A\,Pv$, where

$J = \frac{1}{A}$ = Joule's equivalent = 1,400 ft-lb. per pound-degree centigrade.

The writer derives expressions for the various relations, of which the following are cited here.

Relation between the Entropy and Temperature for the Constant-Volume and the Constant-Pressure Lines. For any constant-volume line, the difference between the entropies at any two temperatures T_2 and T_1, is

$$\phi_2 - \phi_1 = b \log_e \frac{T_2}{T_1} + s(T_2 - T_1) - \frac{u}{2}(T_2^2 - T_1^2)$$

and for constant-pressure lines

$$\phi_2 - \phi_1 = a \log_e \frac{T_2}{T_1} + s(T_2 - T_1) - \frac{u}{2}(T_2^2 - T_1^2)$$

Also, at any given temperature the difference of entropies for the constant-volume lines v_1 and v_2 is

$$\phi_2 - \phi_1 = R \log_e \frac{v_2}{v_1}$$

and for constant-pressure lines P_1 and P_2 is

$$\phi_2 - \phi_1 = -R \log_e \frac{P_2}{P_1}$$

also

$$\phi - \phi(p = 14.7) = 0.0707 (\log_e p + \log_e 14.7)$$

where p is now in lb. per square inch.

On the chart entropy is set off horizontally on an even scale, and an even scale of temperature and uneven scales of total heat and internal energy are set off vertically.

The author discusses in some detail the advantage of representing the six functions of state as a means of simplifying the expressions.

But, besides simplifying the calculation in finding the efficiency of ideal diagrams, the energy chart affords a convenient means of ascertaining, to some extent, the kind of thermal action that goes on in the cylinders of actual gas engines and enables one to obtain a fairly close idea of actual efficiencies.

The writer also shows how the mean pressure can be determined from or checked by means of a practical thermal diagram, which latter gives at once the temperatures at most points of the cycle. In particular, the writer carries through a comparison between a small and large Diesel engine, and finds through a consideration of the compression lines that the larger cylinder and piston are hotter than the smaller. The hot cylinder may account for earlier and better combustion in the larger engine, as the expansion lines on the right (Fig. 9) would indicate. The average temperature of the cylinder and piston surface in the larger engine is seen from the figure to be approximately 750 deg. cent. absolute at the point H, which temperature is near the limit for the best lubricating oils. This indicates the reason for the well-known particular difficulty experienced in keeping cool the piston and internal surface of the cylinder of large Diesel engines.

The nature of the combustion is also well illustrated in Fig. 9. In the larger Diesel engine combustion is nearly complete at 0.4, equivalent to 0.36 of the stroke, and in the small Diesel combustion is almost complete at 0.7 equivalent, to 0.46 of the stroke. The thermal diagram should therefore be of consider-

able service in tuning up engines to give their best indicated results. (*The Journal of the Institution of Mechanical Engineers*, no. 5, July 1917, pp. 333-349, 8 figs., *tA*)

Measuring Apparatus

THEORY OF THE FLEXIBLE-TUBE MANOMETER, H. Lorenz (*Phys. Zeits.*, vol. 18, pp. 117-121, March 15, 1917)

For measuring the pressure of liquids or elastic fluids in industrial processes, the Bourdon flexible-tube manometer plays an important part. The active component of this instrument is a thin-walled metallic tube of oval, i.e., elliptical, cross-section, which is bent into circular shape, the ring, however, not being closed but including an angle of 270 deg. Both ends are closed by soldered covers, and near the fixed extremity the tube carries a support for attachment to the vessel under examination. Pressure causes deformation of the tube, which deformation is communicated to a calibrated recorder fixed to the movable end.

The present paper deals with the theory of this instrument, and first investigates a closed-ring tube possessing a known internal pressure. A previous paper [see Abs. 1335 (1912)] on the bending of curved tubes should be consulted. The distortion produced is found to be directly proportional to the pressure in the flexible tube—a fact which supersedes the previous theory of dependence upon the strength of the tube. Discrepancies between theory and experiment are ascribed to the incomplete elliptical shape of the meridian curve or to the loss of double symmetry of distortion. (*Science Abstracts*, Section A—Physics, vol. 20, part 7, July 30, 1917, no. 235, p. 258, *et*)

Mechanics

COLUMN TESTS AND FORMULÆ, Robert S. Foulds

In the *Engineering News-Record* of June 28, 1917, was given a description of column tests made at the Bureau of Standards. The present article is partly of the nature of comments.

The writer expresses the belief that on account of the erratic tests it is idle to expect plotted results of any particular series of one cross-section to give a smooth curve for a column formula. Further, with erratic results eliminated, different sections with ends squared, as in the Bureau of Standards tests, would probably have varying degrees of end fixity, and this would give curves of different slopes.

The general trend of these tests, as a whole, is seen to follow the direction of the formula $36{,}000\text{-}0.386\ (l/r)^2$, tangent to the Euler curve $\frac{28E}{(l/r)^2}$ at $l/r = 216$. Perfect fixity of the ends is not to be expected—that is, a curve tangent to $4\ \frac{\pi^2 E}{(l/r)^2}$. In column tests with pin ends, one would expect a general slope such as is expressed by a curve tangent to $16\frac{E}{(l/r)^2}$, which end conditions it is believed approximate the end conditions in structures. Had the length l between points of inflection in these tests been measured and the results plotted, they would probably have had the general slope of a curve tangent to $\frac{\pi E}{(l/r)^2}$

The writer believes that too few tests have been made to establish any formula, and besides no one formula for a steel of particular chemical combination would exactly express the facts for various sections and for thin and thick material.

He further believes that had the elastic limits been given, it would have probably been found that the ratio of the elastic limit of the columns tested to their ultimate is roughly equal to the ratio of the elastic limit of full-sized tension members to their ultimate.

As regards working stresses, he claims that a curved-line formula is more rational than a straight-line formula, and believes that in time engineers will adopt a curved-line formula something like the J. B. Johnson parabolic formula, or

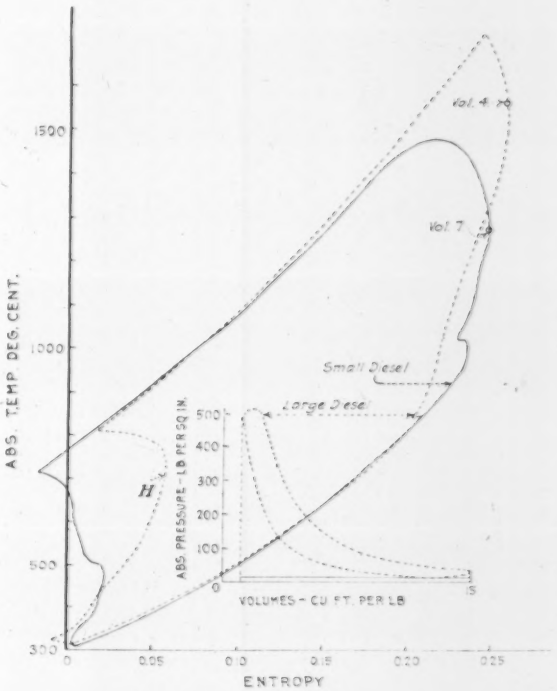


FIG. 9 COMPARISON OF THERMAL DIAGRAMS FOR LARGE AND SMALL DIESEL ENGINES

$36{,}000\text{—}0.7\ (l/r)^2$. (*Engineering News-Record*, vol. 79, no. 6, August 9, 1917, pp. 260-261, *e*)

STANDARDIZING SYMBOLS FOR SCREW-THREAD NOTATION AND FORMULÆ

The Bureau of Standards is considering the symbols given below for use in its work on the standardization of screw-thread gages. In proposing the particular letters given, several points have been in mind, such as the use of symbols which can be found on the ordinary typewriter, and the consistent use of large and small letters.

An attempt has been made to use the large and small letters in a systematic manner which will give the best results. In computations and development formulæ, it is generally most convenient to use the diameter. It has, therefore, seemed desirable to provide symbols for both diameters and radii, and this has been done by using the large letters for the diameters and the corresponding small letters for the radii.

With a few exceptions, the capital letter has been used to indicate the largest quantities and the small, or lower-case, letter the corresponding smaller quantities. This has not been done in the case of the letter "N," as it was thought best to have the upper-case "N" a reciprocal of the upper-case "T," and similarly with the lower-case "n" and "t." The

Bureau will be very glad of constructive criticisms and suggestions from those who are experienced and interested in the subject. The symbols follow:

SYMBOLS FOR SCREW-THREAD FORMULÆ

Full, or outside diameter	D
(Corresponding radius)	d
Pitch or effective diameter	E
(Corresponding radius)	e
Core diameter	K
(Corresponding radius)	k
Angle of the thread	A
(For half the angle)	a
Number of turns per inch	N
Number of threads per inch	n
Lead	P = 1 N
Thread interval	p = 1/n
Helix angle	s
Tangent of the helix angle	S
Width of flat at top and bottom	F
Distance from the flat to point that would be formed if sharp V-thread were used	f
Depth or height of sharp V	H
Depth or height of thread	h

REGARDING WIRE MEASUREMENTS

Measurement over wires	M
Diameter of wire	G
(Corresponding radius)	g
Radius of curvature (Whitworth crest and root)	c

(*American Machinist*, vol. 47, no. 8, August 23, 1917, p. 326, 9)

Pumps

NOTES ON THE CONSTRUCTION OF TURBINE PUMPS, Alan E. L. Chorlton, Mem. Am. Soc.M.E.

Description and discussion of the main elements of construction of turbine pumps. The writer considers the subject under the headings of the various component parts of a pump. These are:

The *stator*, which consists of the casing, or housing, and of the guide vanes, or appliances, for converting velocity energy into pressure energy.

The *impeller*.

The *balancing appliances*, hydraulic or mechanical.

The *rotor* considered as a whole, and including the spindle, with its protecting sleeves, impellers, and, in most cases, the balancing appliances.

The *bed* and other details, bearings, stuffing boxes, etc.

There are two main types of casings; the Osborne-Reynolds, or divided type, sometimes called the ring type, and the Sulzer integral, or one-piece type, sometimes called the cylindrical type. Recent American practice provides a variation of this type with the housing in halves, divided on the horizontal central line.

As regards the guide vane, the writer classifies the various assemblies, or passages, into three groups:

a tangential and radial with return radial
b tangential and spiral
c combinations.

Speaking generally, combination designs are not so efficient as the simple types, owing, probably, to the hydraulic loss through changing the radial direction of the water at high speed.

As regards the finish of guide-passage surfaces, the writer states that for best efficiency, the throat of the passage, at least, if not the entire passage, should be of gun metal or bronze, as iron does not preserve a sufficiently good surface for high-velocity conditions. For best results, a bronze blade should be provided with boxed-in passage, the blade being attached to the guide-vane casting or doweled to the casing.

Impellers are either single-entrant or double-entrant.

Multicellular pumps use a single-eye wheel in three forms: *a*, unbalanced, and equal side areas, one rubbing shoulder; *b*, unbalanced, equal side areas, two rubbing shoulders; and *c*, balanced on paper. Type *c* has the paper advantage of being in balance. Actually it is a poor approximation to a balance. Disturbing factors are set up by differences in side pressure on the impeller due to differences in volume and surface form of the water contained on the two sides of the impeller; by differences of quantitative leakage through the two shoulders, and by high-pressure leakage into one side of the impeller from the stage above and leakage from the other side of the impeller to next low-pressure stage below. Therefore, in practice it is necessary to provide an additional end-balancing device of the hydraulic type, or a mechanically positioning fitting, such as a thrust collar or ball bearing.

The writer discusses in detail the question of how the internal design of all impellers is governed by the two controlling features: the entrance, or inlet angle of vane, and the delivery, or exit angle of the vane.

The balancing appliances are discussed in detail.

As regards the rotor, the question of support is discussed in an interesting manner. The ideal condition is that of a rotor supported in lubricated bearings on a shaft of such sufficient stiffness between supports that the deflection under all possible running conditions is less than the clearance allowed at the neck rings and intermediate bushes, so that no contact takes place between the rotating and the fixed members, the clearance at the neck rings and intermediate bushes being kept down to the smallest possible limits. It is practically impossible to present mathematically the exact conditions with such a number of incalculable factors to take into account.

The supporting effect of the bushes on the shaft in passing through the diaphragm intermediate between the impellers is very difficult to allow for exactly. Intermediate bushes can only, in some cases, be considered as water-lubricated supports, which will act as such so long as a certain low surface pressure on them is not exceeded; but if too great pressure comes on, heating takes place on account of the high-speed of rotation. The author believes that too much use is made of these intermediate supports in turbine-pump design. It is found in practice that an internal bearing to be successful must have the same water pressure at both ends and must be properly lubricated with good grease, and then it gives excellent results. It is, after all, a fact, therefore, that designers are practically dependent on the shaft itself for the necessary strength and stiffness to allow of vane internal clearance, which makes apparent the great importance of a good design which will economically give the minimum deflection of the spindle.

The forms of neck-ring are classified and discussed under the following heads:

a Internal
b External
c Vertical
d Labyrinth

The factors affecting the deflection of a turbine-pump spindle are:

Static
- (*a*) The weight of spindle and distribution of diameter change
- (*b*) The weight and distribution of impellers, balancer, and parts
- (*c*) The number and span of supporting bearings; and

Dynamic
- (*d*) The dynamic condition, other incalculable forces entering into the account, such as centrifugal forces due to the out-of-balance masses, and finally certain hydraulic disturbances.

(*a*) Should be as light as possible consistent with the necessary stiffness, and in common practice spindles are practically parallel the whole length.

(*b*) Impellers and balancer should be grouped together as closely as possible, only allowing sufficient space for the water passages between the stages; also, the entire weight should be brought as close to the supporting bearings as possible.

(*c*) The span of supporting bearings plays such an extremely important part in the durability of the pump; in the possibility and preservation of fine clearances; in the whirling of the shaft and in the determination of the most economical size of spindle, that special notice will be taken of it.

(*d*) A loaded shaft supported horizontally between two bearings will "sag," and when rotated must suffer bending at every revolution. Also, there are bound to be certain out-of-balance masses in the rotor due to keys, heterogeneous composition of material, the unavoidable variation of thickness of castings, etc. In addition, a shaft has vibrational periods due to its length and diameter, the whole question of vibration being intensely complicated by the loading and supports. (*Journal of the Institution of Mechanical Engineers*, No. 5, July 1917, pp. 361-432, 42 fig., *cdA*)

Railroad Engineering

BEACH OIL-ELECTRIC CAR FOR THE NASHVILLE, CHATTANOOGA & ST. LOUIS RAILWAY

Description of an oil-electric car designed to supplant steam-locomotive passenger service in branch-line territory where the slight density of traffic makes such a type preferable. This car is provided with motor-driven trucks, current for which is secured from an oil-engine-driven generator mounted in the forward end of the car. It is stated to be the most powerful self-propelled unit of its kind thus far constructed and is expected to operate at from one-third to one-fifth of the expense required to maintain a corresponding service by steam, in addition to its eliminating smoke, etc.

The power plant consists of a four-cycle eight-cylinder 150-hp. engine direct-connected to a 100-kw. differential-compound-wound 250-volt direct-current generator, running at a constant speed of 1,000 r.p.m.

The engine burns a fixed gas derived from a gas generator which operates on kerosene oil. The gas is supplied directly from the generator into the engine cylinders in the proportion of one part of gas to six parts of air.

The car weighs 113,000 lb. completely equipped, accelerates at a rate of 0.8 miles per hr. per sec. and has a speed of 45 miles per hr. It requires 140 hp. to operate this car at 45 miles per hr. and 340 hp. to accelerate at the above-mentioned rate. As the engine generates 150 hp. and the car when running at 45 miles per hr. consumes only 140 hp., the additional power developed is automatically used to charge the battery.

The car is heated by means of hot water from the engine, which is by-passed when not wanted. The double trucks on which the car is mounted are of the equalized high-speed type with 7 ft. 3-in. wheel base, 33-in. M.C.B. rolled-steel wheels and 5 x 9-in. M.C.B. journals.

The following is believed to be a fair average cost per mile (the cost generally varies with the service required): Wages, $0.0745; fuel and lubrication, $0.04; repairs and supplies, $0.035; depreciation, $0.0385; total cost, $0.188. (*Railway Review*, vol. 61, no. 9, September 1, 1917, pp. 259-260, 3 figs., *d*)

A 120-TON COAL CAR FOR THE VIRGINIAN RAILWAY. B. W. Kadel

Description of one of four experimental cars built for the Virginian Railway without drop doors to unload in the car dumper.

The car is built for use in bituminous-coal-carrying service and has certain features of construction which make it of particular interest.

The car body is of plate-and-angle construction, with Carnegie cross-tie sections for side stakes and end-plate stiffeners. The principle of design is that the weight of the lading be actually transferred to the sides of the car, the integrity of the center sill as a draft member being maintained. The center sill extends not quite to the bolster at either end of the car. The buffing forces are delivered to the center sill, not through the rivets, but as direct loads upon the ends of the sills, and the center plates are integral parts of the steel castings forming a portion of the radial draft gear.

To prevent the center sill from receiving bending stresses of any moment from the lading, three plate-girder diaphragms are provided to carry the load out to the side plate girders. These have the compression members passing continuously over the center sill, and the bottom, or tension, member passing under the sill.

The sides of the car are carried by the body bolsters, which are of novel construction. They are integral steel castings located above the floor of the car within the coal space, and are shaped not only to give an economic and advantageous disposition of the metal for the various conditions of load application, but, at the same time, to offer no obstruction to the coal in dumper. Wing plates extend upward from the outer ends of the bolsters to stay the sides of the car.

Because of the great weight of the car, it has been found necessary to provide definite jacking points specially designed to take care of this operation. Two jacking blocks are provided at each corner of the car, either of which will support

TABLE 1 STRESS LIMITATIONS OBSERVED IN DESIGN OF VIRGINIAN 120-TON COAL CAR

	Stress, lb. per sq. in.		
	Structural Parts	Steel Castings	Rivets
Tension	13,000	9,000	....
Compression	13,000	9,000	....
Shear	9,000	8,000	8,000
Bearing	....	....	16,000

the load of that corner of the car, so that the car can be jacked up at one of these points and stooled at the other. One of these blocks is under the end of, and in reality a part of, a cast-steel body bolster, the other being a part of the corner poling pocket. The push-pole pockets also have bracket portions which extend out and engage stops on the cradle of the dumper, should the overhead clamps for any reason fail to hold the car when in inverted position.

It is stated that the aim in the design has been to eliminate, as far as possible, all useless metal, and to this end an especially careful analysis of the known forces and stresses was made. Under the most extreme conditions of loading the extreme combined stresses have not been allowed to exceed those given in Table 1, based on 10 per cent overload in the car. As far as possible, the secondary stresses have been analyzed and allowed for. The article contains a promise of publishing, at a later date, the method of calculation of stresses for the various portions of this car. (*Railway Age Gazette*, vol. 63, no. 7, August 17, 1917, pp. 285-289, 7 figs., *d*)

Steam Engineering

EXCHANGE OF BASES IN PERMUTITE, Miss G. Kornfeld (*Phys. Zeits.*, vol. 18, pp. 113-114, March 1, 1917. Paper read before the Deutsch. Bunsen Gesell., Dec. 1917.)

Together with V. Rothmund, the author investigated the aluminate-silicates, or permutites, of Gans, considering them to consist of two phases, a solution containing two cations and one anion, and a solid phase (permutite) containing the two cations. The author reviews the researches and formulæ of Wiegner and of Gans, and describes experiments in which powdered sodium permutite was mixed with solutions of silver nitrate and sodium nitrate (simultaneously or separately), and shaken for about five minutes; the concentrations varied within very wide limits. A new formula is deduced and tested by experiments with silver permutite and alkali salts. (*Science Abstracts*, Section A—Physics, vol. 20, part 7, July 30, 1917, no. 235, pp. 301-302, *gt*)

SUGDEN'S SUPERHEATER FOR THE STIRLING TYPE OF BOILER

In the usual arrangement of superheater with this type of boiler the former is placed between the first and second bank of tubes. There are, however, certain particular objections to this arrangement, principally because of the very limited space available for cleaning, removing or replacing either boiler or superheater tubes.

If the superheater is arranged with the headers either above or below the two sets of circulating pipes connecting the steam and water space of the drums, there are certain difficulties; if placed below the expanded joints of the tubes and the joints of the handholes affording access to the headers, they are in the path of the flame and heated gases, which is bad practice. In the alternative arrangement the headers are placed outside the superheater pipes, being inserted between the circulating pipes. This is the objectionable feature of placing the superheater tubes in the chamber between the first and second banks of tubes, as this increases the difficulty of taking out and replacing the boiler tubes as well as the superheater tubes.

In the new design, shown in Fig. 10, the superheater is placed in the first chamber, in close contact with the front wall of the boiler and in such a position that access can be readily obtained for cleaning and inspection. It also avoids any complications in removing either boiler or superheater tubes.

Such an arrangement involves the danger of having the superheater projecting too far into the chamber and burning out. In this case this difficulty was overcome by placing the superheater tubes in a single header so arranged that the front and back rows were not more than about four inches apart, which prevents any excessive heat reaching the tube.

The superheater header is divided into three compartments and consists of two double groups of U-tubes, one group being placed immediately alongside the other.

If a superheater tube should fail, it is not necessary to shut the boiler down, as the tube can be plugged in a few minutes. For this purpose a steam stop valve is placed on the inlet side of the superheater, so that it is only necessary to discharge the steam from the superheater to reëxpand or stopper a tube, which can be done in a few minutes without letting the steam out of the boiler.

The following particulars are given of the working of this

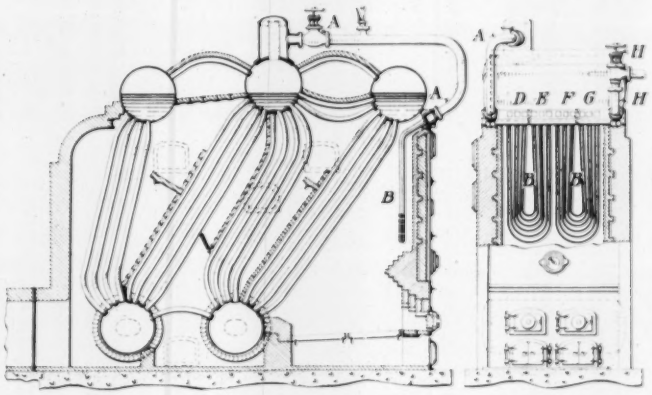


FIG. 10 SUGDEN SUPERHEATER FOR STIRLING TYPE OF BOILER

superheater on a Stirling boiler at the Blaina Colliery. The boiler has a heating surface of 1620 sq. ft. and a grate surface of 32 sq. ft. and is capable of evaporating under normal conditions of working about 6500 lb. of water per hour. The working pressure is 160 lb. per sq. in., giving a temperature of 370 deg. fahr. The superheat added to the steam at this temperature is 180 deg. fahr., making a total steam temperature of 550 deg. fahr. (*Engineering*, vol. 104, no. 2693, Aug. 10, 1917, p. 147, 3 figs., *d*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

The thirty-fifth Annual Convention of the National Association of Stationary Engineers was held at Evansville, Ind., September 10 to 14. The business session included an enlightening paper on How Manual Training Became Vocational Training. This was followed by an appreciative lecture commemorating the one-hundredth anniversary of George Henry Corliss, the inventor of the Corliss engine.

SELECTED TITLES OF ENGINEERING ARTICLES

AERONAUTICS

PHYSICS OF THE AIR, W. J. Humphreys. Journal of The Franklin Institute, vol. 184, no. 2, August 1917, pp. 137-178, 15 figs., (to be continued)

PHYSICS OF THE AIR, W. J. Humphreys. Journal of The Franklin Institute, vol. 184, no. 3, September 1917, pp. 371-408, 9 figs. (to be continued)

ON THE VALUE AND USE OF THE LARGE AIRPLANE, F. Handley Page. Aviation, vol. III, no. 2, August 15, 1917, pp. 96-100, illustrated.

DISTURBING BODIES ON WING SURFACES, Alexander Klemin. Aviation, vol. III, no. 2, August 15, 1917, pp. 100-101, illustrated.

THEORY OF PRESSURE ON A PLANE SURFACE DUE TO RELATIVE WIND, A. E. Watson. Flight, No. 450 (no. 42, vol. 9), August 9, 1917, pp. 815-816, 1 fig. (to be continued)

THEORY OF PRESSURE ON A PLANE SURFACE DUE TO RELATIVE WIND, A. E. Watson. Flight, No. 451 (no. 33, vol. 9), August 16, 1917, pp. 838-840, 5 figs.

CONTROLS AND CONTROL SURFACES, W. J. Waterhouse. Aviation and Aeronautical Engineering, vol. 3, no. 3, September 1, 1917, pp. 160-163, 17 figs.

TESTING VARIABLE-SPEED ENGINE BY A NEW METHOD, Prof. Daniel Roesch. Aerial Age Weekly, vol. 5, no. 26, Sept. 10, 1917, pp. 972, 1 fig.

THE 260-HP. MERCEDES ENGINE. The Automobile and Automotive Industries, vol 37, no. 11, September 13, 1917, pp. 452-455, 8 figs. (second part)

THE 200-HP. MERCEDES. Aerial Age Weekly, vol. 6, no. 1, September 17, 1917, pp. 18-21, 9 figs.

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HIGH PRESSURE AIR COMPRESSOR DESIGN AND APPLICATION, Joseph M. Ford. Canadian Machinery, vol. 18, no. 11, September 13, 1917, pp. 293-298, illustrated.

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WAR CONVENTION OF AMERICAN BUSINESS MEN. American Machinist, vol. 47, no. 11, September 13, 1917, p. 468.

SIXTH ANNUAL SAFETY CONGRESS. Metallurgical and Chemical Engineering, vol. 17, no. 6, September 15, 1917, p. 282.

BOSTON MEETING OF AMERICAN CHEMICAL SOCIETY. Metallurgical and Chemical Engineering, vol. 17, no. 7, September 15, 1917, pp. 283-286.

CONVEYING

COAL AND ASH CONVEYOR TESTS, L. A. Quayle. Power, vol. 46, no. 10, September 4, 1917, p. 325, 2 figs.

ENGINEERING MATERIALS

STANDARD METHODS OF TESTING RUBBER MATERIALS. City of New York Board of Estimate and Apportionment, July 1917, issued by the Bureau of Contract Supervision, 10 pp.

NATIONAL PHYSICAL LABORATORY REPORT ON THE DEPARTMENT OF METALLURGY AND METALLURGICAL CHEMISTRY 1916-1917. Dr. Walter Rosenhain. The Metal Industry, vol. 11, no. 7, August 17, 1917, pp. 121-122.

† TESTING RAILS BY THE QUICK-BEND METHOD. Railway Age Gazette, vol. 63, no. 10, September 7, 1917, pp. 413-415, 4 figs.

ETUDE SUR LA CONDUCTIBILITÉ THERMIQUE DE QUELQUES MATÉRIAUX DE CONSTRUCTION, Mme. G. Bieler-Butticaz. Bulletin Technique, annee 43, no. 15, Juillet 28, 1917, pp. 141-144, 3 figs.
Thermal conductivity of some building materials.

LA TREMPE DE L'ACIER, M. Henry Le Chatelier. Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences, tome 165, no. 5, (30 Juillet 1917), pp. 172-174.
Annealing of steel.

SUR LA CURBURATION DU FER PAR DES CYANURES ET CYANATES ALCALINS, M. Portevin. Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences, tome 165, no. 5, (30 Juillet 1917), pp. 180-182.
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SOME GEOLOGICAL CHARACTERS OF MOULDING-SANDS, Prof. P. G. H. Boswell. The Foundry Trade Journal, vol. 19, no. 188, August 1917, pp. 414-418, 4 figs.

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THE SPONTANEOUS FIRING OF COAL, J. S. Haldane. Transactions of the Institution of Mining Engineers, vol. 53, part 4, August 1917, pp. 194-205.

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VERSUCHE ÜBER DIE REGULIERARBEIT VON FRANCISTURBINEN, Dr. A. Strickler. Schweizerische Bauzettung, bd. xx, nr. 4, Juli 28, 1917, pp. 37-40, Abb. 11.
Tests on governing of Francis turbines.

INTERNAL-COMBUSTION ENGINEERING

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† MCEWEN HIGH-COMPRESSION OIL ENGINE. Power, vol. 46, no. 10, September 4, 1917, pp. 321-323, 7 figs.

THE "BEARDMORE" MARINE OIL ENGINE. Engineering, vol. 104, no. 2695, August 24, 1917, pp. 194-195.

† "SPAR-LENGTHS" IN VARIOUS GASES AND VAPOURS, Robert Wright. Journal of The Chemical Society, vols. 111 & 112, no. 657, July 1917, pp. 643-649.

OIL ENGINES FOR DRY DOCKS. Motorship, vol. 2, no. 9, September 1917, p. 10, 2 figs.

A NEW SURFACE-IGNITION ENGINE. Motorship, vol. 2, no. 9, September 1917, pp. 13-15, 6 figs.

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Method of determining the viscosities of lubricating oil blends.

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DESIGN OF HEAVY HELICAL SPRINGS, G. S. Chiles and R. G. Kelley. Railway Mechanical Engineer, vol. 91, no. 9, September 1917, pp. 477-480, 7 figs. (to be continued)

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PRECISION THREAD GAGES, E. A. Suverkrop. American Machinist, vol. 47, no. 7, August 16, 1917, pp. 265-271, 15 figs.

METAL MACHINE SHOP PRACTICE. The Metal Industry, vol. 15, no. 9, September 1917, pp. 378-379, 10 figs.

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† Abstracted in the Engineering Survey in this issue.

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MIKADO TYPE LOCOMOTIVE, LOUISVILLE & NASHVILLE RAILROAD, Millard F. Cox. Railway Review, vol. 61, no. 10, September 8, 1917, pp. 286-289, 6 figs.

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BOILER-HOUSE DESIGN, Herbert E. Birch. Industrial Management, vol. 53, no. 6, September 1917, pp. 827-837, 6 figs.

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GRAPHICAL SOLUTION FOR CIRCULAR FORMING TOOLS, G. E. Zugelter. American Machinist, vol. 47, no. 7, August 16, 1917, pp. 277-279.

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PHOTOGRAPHY IN COLORS. By George Lindsay Johnson. New ed., E. P. Dutton & Co. *New York, 1917.* Cloth, 5x8 in., 302 pp., 36 illus., $2. Gift of the publisher.

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THE POWER KINK BOOK. Novel Ideas and Simple Devices for Meeting Emergencies in the Power Plant. Power, *New York, 1917.* Boards. 6x8 in., 146 pp., 147 figs. $1.75. Gift of the publisher.

PRACTICAL MARINE ENGINEERING. For Marine Engineers and Students, with Aids for Applicants for Marine Engineers' Licenses. Fourth ed. By Captain C. W. Dyson. Marine Engineering, *New York, 1917.* Cloth, 6 x 9 in., 982 pp., 500 figs. $6. Gift of the publisher.

PRINTING TRADES BLUE BOOK, 1917. A. F. Lewis & Co. *New York, 1917.* Cloth, 6x8 in., 543 pp. $3. Gift of the publisher.

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QUEBEC. REPORT ON MINING OPERATIONS IN THE PROVINCE OF QUEBEC. 1916. *Quebec, 1917.* Purchase.

RAILWAY ESTIMATES. Design, Quantities and Costs. By F. Lavis. McGraw-Hill Book Co., Inc., *New York, 1917.* Cloth, 6x9 in., 608 pp., 99 figs. $5. Gift of the publisher.

RAILROAD FREIGHT RATES AND THE FARMER. By Samuel O. Dunn. An address before the Illinois Agricultural Association. July 6, 1917. Purchase.

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RECENT PRACTICE IN THE SANITARY DRAINAGE OF BUILDINGS: With Memoranda on the Cost of Plumbing Work. By Wm. Paul Gerhard. Second ed., D. Van Nostrand Co., *New York, 1890.* Boards. 4x6 in., 175 pp. $0.50. Gift of the publisher.

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ST. LOUIS-SAN FRANCISCO RAILWAY COMPANY. Report as of Dec. 31, 1916. n. p. *1917.* Gift of company.

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SANITATION PRACTICALLY APPLIED. By Harold Bacon Wood. John Wiley & Sons, Inc., *New York, 1917.* Cloth, 5x8 in., 473 pp., 44 figs. $3. Gift of the publisher.

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STATE SANITATION: A Review of the Work of the Massachusetts State Board of Health. By George Chandler Whipple. Cambridge, Harvard University Press, *Cambridge, Mass., 1917.* Cloth, 6x9 in., 377 pp., 12 plates, 8 diagrams. $2.50. Gift of the publisher.

STEAM TURBINES: A Practical Work on the Design, Selection, Operation, and Maintenance of Steam Turbine and Turbo-Generator Plants. By Walter S. Leland, American Technical Society, *Chicago, 1917.* Cloth, 6x8 in., 137 pp., 116 figs. $1. Gift of the publisher.

STORAGE BATTERIES SIMPLIFIED: *Operating Principles*—Care and Industrial Applications. By Victor W. Page. Cloth 5x8 in., 208 pp., 89 figs. $1.50. Gift of the publisher.

STRENGTH OF MATERIALS. By James E. Boyd. Second ed., McGraw-Hill Book Co., Inc., *New York, 1917.* Cloth, 6x9 in., 380 pp., 254 figs. $3. Gift of the publisher.

STRESSES IN STRUCTURES. By A. H. Heller, revised by Clyde T. Morris. Third ed., John Wiley & Sons., Inc., *New York, 1916.* Cloth, 6x9 in., 374 pp., 230 figs. $2.75. Gift of the publisher.

SURFACE WATER SUPPLY OF THE UNITED STATES, 1913. Part XII. North Pacific drainage basins. (Water Supply paper 362). *Washington, 1917.*

——— ——— 1914. Part VI. Missouri River Basin. (Water Supply paper 386). *Washington, 1917.*

——— ——— Part XI. Pacific Slope Basins in California. (Water Supply paper 391). *Washington, 1917.*

——— ——— Part XII. North Pacific Drainage Basins. (Water Supply paper 394). *Washington, 1917.*

——— ——— 1915, Part V. Hudson Bay and Upper Mississippi River Basins. (Water Supply paper 405). *Washington, 1917.* Purchase.

TELEPHONE PIONEERS OF AMERICA. Proceedings of Fifth Annual Convention, 1915. Gift of National Electric Light Association.

A TEXT-BOOK OF INORGANIC CHEMISTRY. Edited by J. Newton Friend. Vol. VIII: The Halogens and Their Allies. By Geoffrey Martin and E. A. Dancaster. Charles Griffin & Co., Ltd., *London, 1915.* Cloth, 6x9 in., 337 pp., 30 figs. $3. Gift of J. B. Lippincott.

A TEXT ON BRICK PAVEMENTS. By Clark R. Mandigo, Western Paving Manufacturers' Association. *Kansas City, 1917.* Cloth, 5x8 in., 126 pp., 42 figs. $1.50. Gift of the publisher.

THE THEORY AND PRACTICE OF WORKING PLANS. (Forest Organization.) By A. B. Recknagel. 2d ed., John Wiley & Sons, Inc., *New York, 1917.* Cloth, 6x9 in., 265 pp., 20 illus. $2. Gift of the publisher.

TOPOGRAPHICAL DRAWING. By Edwin R. Stuart. McGraw-Hill Book Co., Inc., *New York, 1917.* Cloth, 6x9 in., 126 pp., 54 figs, 1 map. $2. Gift of the publisher.

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U. S. BUREAU OF THE CENSUS. Abstract of the Census of Manufactures, 1914. *Washington, 1917.* Purchase.

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USE OF THE PANORAMIC CAMERA IN TOPOGRAPHIC SURVEYING. WITH NOTES ON THE APPLICATION OF PHOTOGRAMMETRY TO AERIAL SURVEYS. (U. S. Geological Survey. Bulletin 657). *Washington, 1917.* Purchase.

THE WAR AND BUSINESS. By Otto H. Kahn.. *New York, 1917.* Gift of author.

WAR TAXATION, SOME COMMENTS AND LETTERS. By Otto H. Kahn. *New York, 1917.* Gift of author.

WASHINGTON ACADEMY OF SCIENCES. Directory, 1917. *Washington, 1917.* Gift of Washington Academy of Science.

WATER PURIFICATION. By Joseph W. Ellms. McGraw-Hill Book Co., Inc., *New York, 1917.* Cloth, 6x9 in., 485 pp., 149 figs. $5. Gift of the publisher.

WINTER TRACK WORK. By E. R. Lewis. Railway Educational Press, Inc., *Chicago, 1917.* Cloth, 5x8 in., 166 pp., 21 illus. $1.60. Gift of the publisher.

A WONDERFUL FIFTY YEARS. By Edwin T. Holmes. Privately published (copyright), *1917.* Cloth, 6x9 in., 133 pp., 155 illus. Gift of the author.

THE WOOL INDUSTRY. Commercial Problems of the American Woolen and Worsted Manufacture. By Paul T. Cherington. A. W. Shaw Co. *Chicago* (copyright), *1916.* Cloth, 5x8 in., 261 pp. $2.50. Gift of the publisher.

GIFT OF GEORGE L. FOWLER

INTERNATIONAL RAILROAD MASTER BLACKSMITHS' ASSOCIATION. Report of the Proceedings of the 15th Annual Convention, 1907.

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION. Proceedings of Annual Convention, 23, 29, 30, 1892, 1898, 1899.

TRAVELING ENGINEERS' ASSOCIATION. Proceedings of the 14th Annual Convention, 1906.

GIFT OF PORTLAND CEMENT ASSOCIATION

CONCRETE IN THE COUNTRY.

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A. S. M. E. Accessions

AIR BRAKE ASSOCIATION. Proceedings of the 24th Annual Convention. *New York, 1917.* Gift of Association.

AN AUTOMATIC STARTER FOR INDUCTION MOTORS. By H. F. Stratton. A paper presented before the Association of Iron and Steel Electrical Engineers, May 26, 1917.

THE CHARACTER OF THE BRITISH EMPIRE. By Ramsay Muir. *London, 1917.* Gift of W. Macneile Dixon.

NATIONAL MACHINE TOOL BUILDERS' ASSOCIATION. Proceedings 15th semi-annual convention, 1917. Gift of Association.

NEW YORK CITY, BOARD OF ESTIMATE AND APPORTIONMENT. Standard Methods of Testing Rubber Materials. July, 1917. *New York, 1917.* Gift of Board of Estimate and Apportionment.

NEW YORK CITY, BOARD OF WATER SUPPLY. Information for bidders forms of bid, contract, bond and certificates, specifications and drawings for furnishing and delivering a portable steel building and a truck, erecting a brick storage building at 140th Street and Fifth Avenue and doing miscellaneous work. (Contract 1811, 1917. Gift of Board of Water Supply.

——— ——— Information for bidders, forms of bid, contract, bonds and certificates, specifications and drawings for furnishing and delivering gate and pressure regulating valves and appurtenances for the City tunnel of the Catskill Aqueduct in the City of New York, 1917. (Contract 1881. Gift of Board of Water Supply.

NEW YORK STATE, STATE ENGINEER AND SURVEYOR. Annual Report, Supplement. Vol. II, 1916. *Albany, 1917.* Gift of State Engineer and Surveyor.

NOTES ON THE CONSTRUCTION OF TURBINE PUMPS. By A. E. L. Chorlton. (Excerpt minutes of proceedings of the meeting of the Institution of Mechanical Engineers, May 18, 1917).

PRODUCING THE EVIDENCE IN THE CASE OF THE CHESAPEAKE AND DELAWARE CANAL. Extension of remarks of Hon. J. Hampton Moore of Pennsylvania, June 26, 1917. *Washington, 1917.*

ST. LOUIS PUBLIC LIBRARY. Annual Report, 1916-1917. *St. Louis, 1917.* Gift of Library.

WATTUPPA WATER BOARD. Annual Report to the City Council of the City of Fall River, Mass. 43, 1917. Gift of Wattuppa Water Board.

TRADE CATALOGUES

BOWSER, S. F., & COMPANY. Fort Wayne, Ind. Catalogue of oil filtration devices. Catalogue of oil storage and distribution in the factory.

PERSONALS

IN these columns are inserted items concerning members of the Society and their professional activities. Members are always interested in the doings of their fellow-members, and the Society welcomes notes from members and concerning members for insertion in this section. All communications of personal notes should be addressed to the Secretary, and items should be received by October 16 in order to appear in the November issue.

CHANGES OF POSITION

M. A. NEELAND has been elected president of the New York Shipbuilding Corporation, Camden, N. J.

G. C. HYDE, formerly engineer with the Kentucky Utilities Company, Louisville, Ky., has entered the service of the Southern Indiana Power Company, Bedford, Ind.

J. CLYDE PARMELY, superintendent of the St. Clair County Gas and Electric Company, Belleville, Ill., has become identified with the Luzerne County Gas and Electric Company, Plymouth, Pa.

ROBERT PIERPONT, until recently connected with the Remington Arms Company, Chester, Pa., as superintendent, has become associated with the Dalton Manufacturing Company, of New York.

REUBEN M. STEE, contractor, located at Dozey, N. D., has recently become associated with the Sheyenne Valley Light and Power Company, Inc., Valley City, N. D.

DANIEL E. KEHOE, formerly associated with Kehoe's Iron Works, Savannah, Ga., is now located at the Charleston Navy Yard in the hull division, as assistant shop superintendent.

W. L. BEAN, who has been acting as assistant to the president of the N. Y., N. H. and H. R. R. Company, New Haven, Conn., has been appointed assistant to general mechanical superintendent.

GEORGE W. WILDIN, general mechanical superintendent of the N. Y., N. H. and H. R. R. Company, New Haven, Conn., has been appointed general manager of that company, succeeding C. L. Bardo.

GUY C. PITTS, formerly assistant to yard engineer, Sun Shipbuilding Company, Chester, Pa., has entered the service of the Federal Shipbuilding Company, New York, as assistant mechanical engineer.

JOHN E. LOVELY has severed his connection with the Fort Dearborn Manufacturing Company, Sterling, Ill., and has accepted a position with the Vermont Farm Machine Company, of Bellows Falls, Vt.

ARTHUR B. NEWHALL, formerly instructor of applied science at Wentworth Institute, Boston, Mass., has become identified with the Hood Rubber Company, Watertown, Mass.

F. J. RYAN resigned from the Snyder Electric Furnace Company on June 1, to take up the duties of general manager of the Electric Furnace Construction Company, Philadelphia, Pa.

JOHN A. RANDALL, head of the department of physics at Pratt Institute, Brooklyn, N. Y., has resigned to enter the employ of the Toledo Scale Company in an engineering capacity.

R. BURDETTE DALE has resigned as chief engineer of the Erie City Iron Works, Erie, Pa., and has accepted a position in the planning department of The Franklin Manufacturing Company, Franklin, Pa.

JOHN J. HARMAN, assistant chief engineer with the Elliott and Harman Engineering Company, Peoria, Ill., has become affiliated with the Walworth Manufacturing Company, of Kewanee, Ill.

MAX M. SHAW has become affiliated with the Merchant Mill of the Bethlehem Steel Company, South Bethlehem, Pa. He was formerly connected with Wentworth Institute, Boston, Mass.

CHARLES J. BAMFORD, formerly affiliated with the Agasote Millboard Company, Trenton, N. J., as chief engineer, has become associated with the Buffalo Cold Storage Company, of Buffalo, N. Y.

J. G. MALONE has accepted a position as engineer with The Roessler and Hasslacher Chemical Company, Perth Amboy, N. J. He was until recently connected with the Hercules Powder Company, of Parlin, N. J.

ARTHUR C. HUBBELL, formerly machine designer with C. D. Enochs, of Minneapolis, Minn., has become identified with the Purchasing Bureau of Small Arms, New York, in the capacity of United States inspector.

J. B. FREEMAN has resigned his position as chief engineer of the Webster Engineering Company, Chicago, Ill., and has accepted a similar position with the Du Pere Manufacturing Company, of the same city.

GEORGE J. STURMFELSZ, JR., has resigned the position of boiler house engineer with E. I. duPont de Nemours and Company, City Point, Va., to accept the position of superintendent of boilers with the Bethlehem Steel Company at their Sparrows Point, Md., plant.

HENRY SWIFT has severed his connection with The American Steam Gauge and Valve Manufacturing Company of Boston, Mass., and is now associated with The Cincinnati Ball Crank Company, of Cincinnati, Ohio, as chief engineer.

JAMES P. CALDERWOOD has resigned as associate professor of mechanical engineering in Pennsylvania State College, State College, Pa., and has accepted a position in the technical research department of the Travelers Insurance Company, Hartford, Conn.

JAMES T. GRATIOT has severed his connection with Fairbanks, Morse and Company, Denver, Colo., as manager of the machinery department, and has assumed the duties of manager of the Coliseum Garage Company, Casper, Wyo.

ALTON A. RICHARDSON, until recently identified with the Castner Electrolytic Alkali Company, Niagara Falls, N. Y., in the capacity of assistant engineer, has accepted the position of engineer with the National Electrolytic Company, Canal Basin, Niagara Falls, N. Y.

ROLAND F. HETZEL has resigned his position as shop instructor in the Seattle Public Schools, Seattle, Wash., to accept a position in the engineering department of the Ames Shipbuilding and Drydock Company, of the same city.

CLARENCE P. MACARTHUR, for the past five and a half years master mechanic of the Bowen Manufacturing Company, of Auburn, N. Y., has resigned to accept the position of general foreman with the Wagner Electric Manufacturing Company, of St. Louis, Mo.

BURTON C. FONDA has become affiliated with the New York office of The F. W. Horne Company, of Tokio, Japan. He was formerly connected with the turbine department of the General Electric Company, Schenectady, N. Y.

J. E. GIBSON, formerly in the employ of the American Pipe and Construction Company, Philadelphia, Pa., as principal assistant engineer, has assumed the position of manager of the water department of the Charleston Light and Water Company, Charleston, S. C.

W. S. JONES, of Philadelphia, who has been associated with the Midvale Steel Company in its general sales department, has been chosen vice-president of the Vanadium Alloys Company, of Pittsburgh, Pa.

GEORGE M. SMITH, until recently associated with Walter Rachals and Company, Youngstown, Ohio, as chief engineer, has become connected with the Interstate Iron and Steel Company, Chicago, Ill., in a similar capacity.

LOUIS M. ZACH, formerly mechanical engineer and designer with the Anaconda Copper Company, and International Smelting Company, Tooele, Utah, has accepted a similar position with the Public Works office, Washington Navy Yard, for the period of the war.

DONALD C. WRIGHT, formerly production manager of the Remington Arms-Union Metallic Cartridge Company, Ilion, N. Y., in charge of Enfield contracts, has become affiliated with the Dodge Manufacturing Company, Mishawaka, Ind., in the capacity of production manager.

J. N. HELFBRINGER has resigned from the position of power-plant engineer with the Firestone Tire and Rubber Company, Akron, Ohio, to accept the position of superintendent of power plants with the Kansas Gas and Electric Company, with headquarters at Wichita, Kan.

G. G. CREWSON, until recently connected with the Roessler and Hasslacher Chemical Company, Perth Amboy, N. J., as mechanical engineer, has become associated with E. I. du Pont de Nemours and Company, Wilmington, Del., in a similar capacity.

ROBERT H. WALLACE has entered the employ of the Alignum Products Company, South River, N. J., in the capacity of factory manager. He was formerly shop superintendent of the Bailey Meter Company, Cambridge, Mass.

FRANK E. WILDER, who has been consulting engineer with the Southwark Machine Company, of Portland, Me., for some time, will remove to Bristol, Conn., where he has taken a position on the engineering staff of the New Departure Manufacturing Company.

BEN. G. ELLIOTT, until recently associate professor of mechanical engineering at the University of Nebraska, Lincoln, Neb., has become affiliated with the University Extension Division of the University of Wisconsin, Madison, Wis.

EDMUND BARANY, machine designer of the Singer Manufacturing Company, Elizabeth, N. J., has assumed the duties of mechanical engineer and assistant to general superintendent of the Cleveland Twist Drill Company, Cleveland, O.

R. J. S. PIGOTT, New York district manager for Sanford Riley Stoker Company and B. F. Sturtevant Company, has become identified with the Bridgeport Brass Company, Bridgeport, Conn., as superintendent of the raw-material departments.

FREDERICK W. GAY, formerly associated with The J. G. White Engineering Corporation, San Francisco, Cal., has assumed the position of general manager of the New York office of the Pelton Water Wheel Company.

CHARLES L. FISCHER has accepted the position of master mechanic with the Willard Storage Battery Company, Cleveland, Ohio, after twelve years of service with the Pennsylvania Lines West of Pittsburgh.

ERNEST O. HICKSTEIN, recently identified with the U. S. Indian Service, Pawhuska, Okla., as natural-gas engineer, has again become affiliated with the Empire Gas and Fuel Company, Bartlesville, Okla., in the research department.

EDWARD R. FEICHT, formerly master mechanic of the Federal Dyestuff and Chemical Company, Kingsport, Tenn., has assumed the duties of assistant superintendent of plant of the Bridgeport Brass Company, Bridgeport, Conn.

CHARLES J. MANUEL, formerly chief draftsman of the tool department of the Aeromarine Plane and Motor Company, Keyport, N. J., has become affiliated with the forging department of the American Can Company, Edgewater, N. J., in the capacity of chief draftsman.

MAURICE L. BULLARD has entered the employ of L. H. Shattuck, Inc., agents for the U. S. Shipping Board, Emergency Fleet Corporation, in the construction of a ship yard and also the building of wooden hulls. Mr. Bullard was recently associated with the W. H. McElwain Company, Manchester, N. H., in the capacity of chief engineer.

HENRY C. BERRIAN, until recently connected with the engineering department, estimating division, of the Newport News Shipbuilding and Dry Dock Company, Newport News, Va., has become affiliated with the Federal Shipbuilding Company, New York.

R. A. SMART, formerly assistant manager of works of the Westinghouse Electric and Manufacturing Company, and later in charge of the American and Canadian plants of the Oliver Chilled Plow Works as works manager, is now associated with the Tacony Steel Company and the Tacony Ordnance Corporation, of Tacony, Philadelphia, Pa.

HARRY J. KLOTZ has obtained a leave of absence from his position as operating engineer for the Decatur Railway and Light Company, Decatur, Ill., and has accepted, for an indefinite period, the position of instructor in the School of Aeronautics which the University of Illinois is conducting for the Government at Champaign.